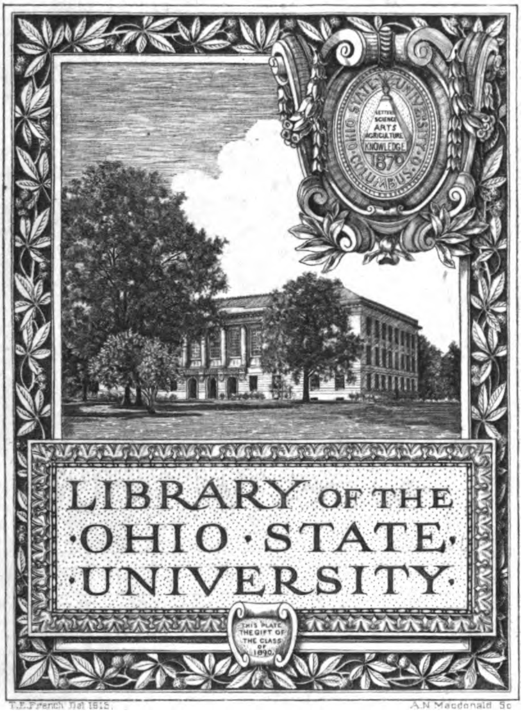
The Junior Institution of Engineers.

JOURNAL AND RECORD OF TRANSACTIONS.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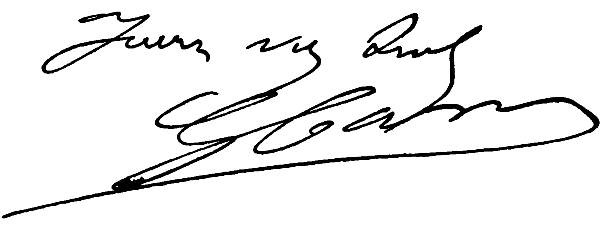

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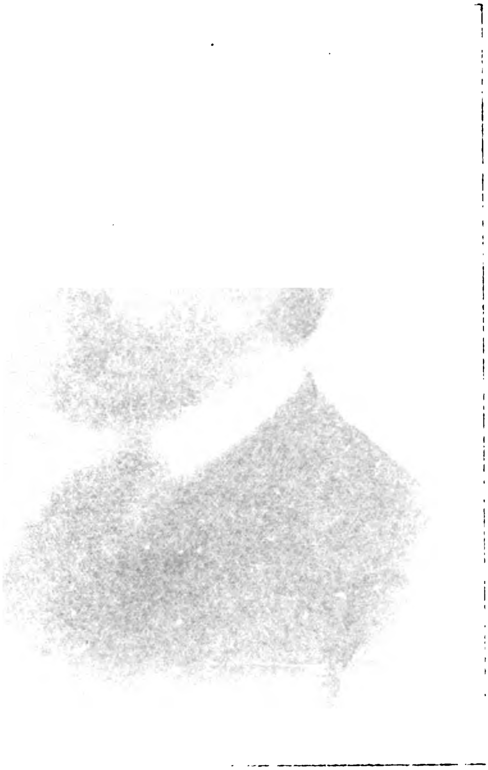

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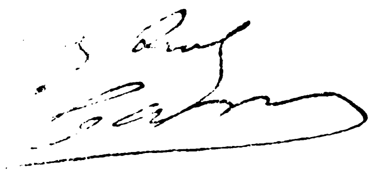

The Junior Institution of Engineers.

GUSTAVE CANET.

(Past-President of the Institution of Civil Engineers of France).

PRESIDENT 1907-8.

JEAN BAPTISTE GUSTAVE ADOLPHE CANET was born at Belfort (Department du Haut Rhin), on September 29th, 1846. After passing through the Ecole Centrale, he obtained the diploma of "Ingénieur des Arts et Manufactures" on August 31st, 1869. He was thus a young Engineer when the Franco-Prussian War was declared, and in this capacity was gazetted as Lieutenant in the Artillery in the "Garde Mobile" of the "Haut Rhin." He was ordered to Neuf-Brisach, where he was present at the siege of the town, taking an active part in the construction of its fortifications, and afterwards was made a prisoner of war, and sent to Leipzig. It was thus that his particular interest in artillery was awakened, and in 1872 he obtained an appointment as an engineer at the factory of guns, gun-carriages and torpedoes of the London Ordnance Works Company belonging to Mr. Vavasseur. Under his able direction, M. Canet propounded as early as 1876, the theory of hydraulic brakes and the new principles for gun carriage construction, which have since been universally adopted. He remained at the Vavasseur Works till 1881, when he left in order to realise his ambition of establishing in France the manufacture of war materials. He did not hesitate to return to his native country to commence operations at the "Forges et Chantiers de la Mediterranée," although he had only obtained from his Government very limited provisional rights for the home manufacture of ordnance. In 1885, a Bill was passed in the French Parliament, authorising the free manufacturing of war materials for foreign Governments. The Ordnance Works established at Le Havre were at once considerably extended, and now all types of ordnance for coast defence, siege, fort and field artillery are manufactured there. M. Canet has equipped a great number of foreign warships with guns, and has also supplied for various countries the new type of turrets or barbettes with central loading arrangements worked hydraulically, electrically, and by hand. In 1897, at the request of the French Government, he amalgamated his works with those of Messrs. Schneider, of Creusot, in order to

create a standard type of artillery in France known as "Schneider Canet," The fusion with these great French steel works gave a considerable impetus to the manufacture of ordnance just at the time when all powers were contemplating the re-armament of their field artillery. The field gun "Schneider Canet," with its long recoil taken up by an hydro-pneumatic brake on the gun carriage was introduced, and has since been adopted by the Japanese, Mexican, Bulgarian, Norwegian, Servian, Spanish, Portuguese, Peruvian, Chinese, Bolivian and other Governments. Notwithstanding being so actively employed on these great works, M. Canet has always found time to take a keen interest in a large number of technical, scientific and philanthropic Institutions, and is a member of the principal representative societies in France and other countries. The value of his work has been recognised by nearly all the Governments of the world in awarding him many honorary distinctions.

The Junior Institution of Engineers (Incorporated).

Founded in 1884 for the Junior Members of the Profession.

JOURNAL AND RECORD OF TRANSACTIONS.

VOLUME XVIII.

TWENTY-SEVENTH SESSION, 1907-1908.

Edited by WALTER T. DUNN, F.C.I.S.
(Secretary to the Institution),
for the PUBLICATIONS COMMITTEE,

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1908.

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The Junior Institution of Engineers.

TWENTY-SEVENTH SESSION, 1907-1908.

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(*Past President of the Institution of Civil Engineers of France*).

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Visits to Works, Inspections, &c.

Miscellaneous.

Part 1. **OCTOBER, 1907.** **Vol. XVIII.**

The Junior Institution of Engineers

(Incorporated).

President - - WILLIAM B. BRYAN, M.Inst.C.E.
President-Elect - M. GUSTAVE CANET.
Chairman - - LEWIS H. RUGG, Assoc.M.Inst.C.E.

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

11th October, 1907.

ANNOUNCEMENTS.

FRIDAY, 18th October, at 7 p.m., at the Westminster Palace Hotel, **Annual General Meeting of the Institution,** followed by the **Annual General Meeting of the Benevolent Fund.**

At 8 p.m., a Paper on "**The Economic Design of Hollow Shafts,**" will be read by Professor W. E. LILLY, D.Sc. *(District Member of Council for Ireland).*

FRIDAY, 25th October, at 7 p.m. Visit: "The Model Engineer" Exhibition at the Royal Horticultural Hall, Vincent Square, Westminster, by the kind invitation of the Organisers, Messrs. Percival Marshall and Co.

Admission on production of Badge of Membership.

SATURDAY, 26th October, at 2.30 p.m. Visit: The Blackfriars Bridge Widening Works. Members to assemble at entrance on Embankment.

Admission on production of Badge of Membership.

MONDAY, 18th November. Meeting at 8 p.m. at the Institution of Civil Engineers, Great George Street, by the kind permission of the Council. Presidential Address by **M. Canet,** on "**The Latest Improvements in English and French Modern Artillery.**"

SATURDAY, 23rd November, at 10 a.m. Visit: The Royal Arsenal, Woolwich. Members intending to be present are requested to inform the Secretary **not later than 19th November.**

FRIDAY EVENING RE-UNIONS. The Rooms of the Institution are kept open every Friday evening during the months of October to May, inclusive, for the purpose of social intercourse amongst the members.

LIST OF MEMBERS, NEW EDITION. Members can obtain a copy on application to the Secretary.

BINDING OF TRANSACTIONS, VOL. XVII., 1906-7. Arrangements have been made for binding Vol. XVII., as usual. Members wishing to avail themselves thereof are requested to send the twelve monthly parts to the Institution **not later than the 31st October,** in accordance with the circular now issued.

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

BROOKS, STANFORD MORTON; 4 Queen Victoria Street, London, E.C.

CORREA, RAYMOND; Messrs. Everett, Edgecumbe and Co., Hendon.

COSTIGAN, JOSEPH CHARLES; Ducros Mercedes Motor Co., 132-6 Long Acre, London.

EVANS, HAROLD; Coventry Ordnance Works, 30 Broadway, Westminster.

GLENN, GEORGE FREDERICK; Messrs. the Seyssel and Metallic Lava Asphalte Co., 42 Poultry, E.C.

HUGGETT, SYDNEY GEORGE GILLESPIE; Messrs. Dorman, Long and Co., 19 Victoria Street, Westminster.

JOBLINGS, VIVIAN; Messrs. Vickers, Sons and Maxim, 32 Victoria Street, Westminster.

MARTIN, HAROLD MEDWAY; "Engineering," Bedford Street, London, W.C.

MURRAY, EDWARD WILLIAM; Electrical Department, Somerset House, Strand, W.C.

OGILVIE, JOHN A. G.; Messrs. Everett, Edgecumbe and Co., Hendon.

PRESS, WILLIAM EDWARD; Messrs. John Aird and Sons, Belvedere Road, Lambeth, S.E.

SINCLAIR, WILLIAM WALLACE; Engineer, P. and O. S. N. Co., 122 Leadenhall Street, E.C.

SINGLETON, CUTHBERT; Great Western Railway, Electrical Engineer's Department, Generating Station, Park Royal.

SMITH, STEPHEN CHARLES; Assistant Works Manager, Coventry Ordnance Works, Coventry.

THORPE, WILLIAM; Messrs. Babcock and Wilcox, Marine Department, Oriel House, Farringdon Street, E.C.

WATES, SIDNEY BENJAMIN; Messrs. Ellington and Woodall, Palace Chambers, Westminster, S.W.

WESTON, JOHN; Messrs. the Trussed Concrete Steel Co., Caxton House, Westminster, S.W.

WHITSON, RALPH ALEXANDER; Government Offices, Masern, Basutoland, South Africa.

WILKINSON, ARTHUR ROWLAND; Messrs. T. G. White and Co., 9 Cloak Lane, Cannon Street, E.C.

WIMBERLEY, WILLIAM BEVILLE THOMAS; Messrs. W. A. S. Benson and Co., 82 New Bond Street, W.

Proposed for election to the class of "Associate."

BIRD, HENRY CHARLES; Tilbury Contracting and Dredging Co., Providence Wharf, East Greenwich, E.

KING, GEORGE OSWALD; Messrs. Arnold Goodwin and Co., 56 Sumner Street, Southwark, S.E.

LOWKE, HAROLD AUSTIN BASSETT; Messrs. D. G. Somerville and Co., Town Quay, Southampton.

MUNDAY, GEORGE CAMPBELL; Messrs. George Munday and Sons, Trinity Square, London, E.C.

SARJEANT, RALPH LIONEL; Mechanical Engineering Department, Finsbury Technical College, Leonard Street, E.C.

Transferences.

The Council have transferred MR. THOMAS GERMANN, Gell Telegraphic Appliances Syndicate, and MR. HENRY HAYWARD GREY, Messrs. Clark and Stansfield, 111 Victoria Street, Westminster, from the class of "Associate" to that of "Member."

PERSONAL NOTES.

F. D. ARUNDEL is arranging to return to Nelson, British Columbia, this month, on mining machinery work in connection with smelting plant.

JOHN BARSON is now engaged with the Vauxhall and West Hydraulic Engineering Co., of Luton, in their hydraulic department, on the installation of plant at Hayes, Middlesex.

STAFFORD X. COMBER has left the Cleveland and Durham Electric Power Company, and has returned to Messrs. S. Pearson and Son, Ltd., Contractors, of 10 Victoria Street, Westminster. He

is now engaged as Assistant Engineer on the contract for the construction of the four East River Tunnels for the Pennsylvania Rail Road, New York. Address—110 Madison Avenue, Flushing, New York.

RICHARD FORSTER, of Hope Villa, High Green, Sheffield, is about to leave England for New Zealand, on medical advice.

H. T. GOULD has gone into partnership with Mr. Jas. Lawson under the style of Lawson and Gould, Mechanical Engineers, of 4 Church Street, Cardiff, and 39 Victoria Street, Westminster.

HENRY GREENLEY has commenced business on his own account at 46 Bruce Grove, Watford, as a specialist in model and small power engine design, and has started works for the manufacture of model boat hulls.

W. H. HAWTAYNE is leaving England again for his second term as Junior Assistant Engineer on the Lagos Government Railway, Oshogbo Extension, Lagos, West Africa.

H. R. HYATT has returned to England from Malta, and is at the Royal Marines Depôt, Deal.

JAMES OSWALD has been elected a member of the Institution of Mechanical Engineers, and a member of Council of the British Foundrymen's Association.

ARCHIBALD R. PAUL has become Assistant Manager of the Medway Steel Works, Strood, Kent.

HENRY POWELL has been appointed Works Manager to the Northern Manufacturing Co., Ltd., Gainsborough.

C. A. SMITH has been appointed Assistant Professor of Civil and Mechanical Engineering at the East London College.

H. A. STEWART has accepted the post of Assistant to Mr. J. M. V. Money-Kent, A.M.Inst.C.E., &c., Consulting Engineer, 25 Old Queen Street, Westminster, and is now engaged in superintending the reconstruction of plant, &c., being carried out at the Cape Copper Works and English Crown Spelter Works, Swansea, South Wales.

HAL WILLIAMS gave the first of the series of lectures which form one of the features of the Engineering and Machinery Exhibition, his subject being "Gas Engines and Suction Gas Plants."

CECIL G. YOUNG sails from Barry Dock for Hong Kong next week, having been appointed fourth Engineer on the S.S. "Ganges," of the Mercantile Steam Shipping Co.

Appointments.

105. Several Mechanical Engineering Draughtsmen are required by a firm at Birmingham; experience in steam engine design essential.

207. Member, age 27, nine years experience in Hydraulic and General Engineering work, shops and drawing office, seeks appointment.

Changes of Address.

BENTALL, C., "Holts," Upper Mildmay Road, Chelmsford.

COMBER, S. X., 110 Madison Avenue, Flushing, New York, U.S.A.

GOODMAN, R. C., 132 Albert Road, Jarrow-on-Tyne.

HUGHES, GEO. H., 43 The Parade, Walton-on-the-Naze; and Messrs. Warner and Co., Walton-on-the-Naze.

HYNE, H. E., c/o Post Office, Saltcoats, Ayrshire, N.B.; and Messrs. Nobel's Explosive Co.'s Works, Stevenston, Ayrshire, N.B.

MILLS, J. A., 27 Cato Road, Clapham, S.W.

MUSTART, J. W., 11 Park Avenue, North Shields.

PHILLIPS, W. A., 186 The Broadway, W. Hendon, N.W.

ROYDHOUSE, E. F., Sandringham, Westcliff Avenue, Westcliff, Southend.

SMITH, EDWIN, 184 Westwood Street, Peterborough; and Messrs. Werner, Pfleiderer and Perkins, Westwood Works, Peterborough.

SPALDING, P. A., 5 University Road, Galway.

STEVENS, CHAS., "Ellesmere," Heber Road, Cricklewood.

FROM THE STARTING PLATFORM.

THE FUTURE OF AERIAL NAVIGATION.

The question of navigating the air is one which the engineer regards from a somewhat different standpoint to that of most other people. With the great body of the public the matter is associated with a limited number of enthusiasts who believe that in the immediate future the air will be traversed by self-propelled machines for ordinary purposes of communication, and as a result is regarded with considerable scepticism. To the engineer, however, the problem is simply a mechanical one, which he would take up professionally, if he had the ordinary inducements to do so.

The truth is that on the one hand for ordinary commercial purposes there is at present no demand whatever for aerial ships; on the other hand the dangers, the risks, and the great expense which attends the use of anything beyond mere drift balloons, whether navigable balloons or true flying machines, prevent the subject being regarded at present as a legitimate field of commercial enterprise.

These remarks, however, would equally well have applied at

one time to the navigation of the ocean itself, and one of the questions in the minds of the rising generations of engineers is whether the next century will witness as great a progress in the navigation of the air as the past century has done in the navigation of the water.

I am afraid an answer to the question cannot be given as a precise numerical statement, though in an article on ballooning, a young American aeronaut, Mr. Leo Stevens, remarks: "It is safe to say that in less than ten years transatlantic airships will be in line between New York and abroad." He further adds: "New York will be the world's great air port, and we shall all live to see it." The last remark is, from one point of view, comforting, but I am afraid that it will not do to pin too much faith to either of the ideas contained in it. Neither can we safely apply the analogy of the automobile, the progress of which I have seen several times lately employed to predict similar rapid advances in aerial automobilism.

As a matter of fact the conditions of aerial locomotion are so vastly different to those of locomotion on land, or even water, as to bear no comparison to each other. The real difficulty of the problem arises from the tremendous and sudden disturbances of the medium in which the airship has to be supported, as well as the difficulty of providing for the continuous sustaining power of a vessel in the air. These causes certainly appear to militate against the commercial developments of the airship in the near future, and exist in spite of recent developments in both balloons and flying machines. My own view of the case closely agrees with that admirably expressed by the eminent American engineer, Mr. O. Chanute, who has done so much for the science of aerial navigation. In an article on the subject, he writes:—"It seems to me quite certain that flying machines can never carry even light and valuable freights at anything like the present rates of water or land transportation, so that those who may apprehend that such machines will, when successful, abolish frontiers and tariffs are probably mistaken. Neither are passengers likely to be carried with the cheapness and regularity of railways, for although the wind may be utilised at times and thus reduce the cost, it will introduce uncertainty in the time required for a journey. If the wind is favourable a long journey may be made very quickly, but if adverse the journey may be

slow or even impracticable." It might possibly be better to modify the too final expression "never" by adding the words, "unless by the aid of inventions and discoveries, the possibility of which has not as yet been even suggested."

If from the commercial side we turn to the navigation of the air as a sport or method of exploration, or as a means of offence or defence in time of war, we are on entirely different ground. Already more than one millionaire has placed an order for a dirigible balloon, in the same way that he would do for a steam yacht, although apparently, not many opportunities present themselves to cruise in such an air ship. The difficulty in the way of the practical use of the balloon is pretty well shown by the failure a second time of Mr. Wellman, although backed by almost unlimited financial resources. Nevertheless, according to the ubiquitous "Daily Mail" reporter, Mr. Wellman is as hopeful as ever, and means to try again, confident that he can reach the North Pole by this means. Let us hope that if he does so, the pluckly explorer will be able to also safely return.

It is, however, in regard to the military balloon and flying machine the greatest sums of money are likely to be spent, and the greatest developments are to be expected. France, England and Germany have led the way in this matter, and just as with the submarine, the lead given by one or more nations must undoubtedly be followed by others.

For military purposes any risks and even sacrifice of life will not deter practical experiments in aerial navigation any more than they have deterred the progress of the submarine. It is probable that the proportionate death record in the sport of ballooning and flying beats even that of the automobile itself, but this fact is little likely to deter others from such pursuits. Thus, the progress of aerial navigation, which up to the present has only been spasmodic, having from time to time received an occasional impetus and then ceased to excite any more attention, is now, as the result of such modern inventions as the petrol motor, certain to move continuously forward.

The whole question is simply one of money, and there is nothing as far as the mere mechanical side of the problem is concerned to prevent before long a voyage being made round the world on an airship or even the dream of the poet so often quoted in regard to the war of aerial navies becoming an additional incentive to universal peace.

H. S. HELE-SHAW.

OBSERVATIONS IN GENERAL.

We offer our congratulations to the Royal Geological Society on the attainment of its centenary on the 26th September. Sir Archibald Geikie delivered his Presidential Address to the Society on the same date, and concluded by expressing the hope that the representatives of other countries who had attended to offer their felicitations might carry away with them an impression that the Society after a lapse of a hundred years, had not entered upon a stage of senile decay, but was still young, vigorous and enthusiastic, working confidently forward to a career in the future not less successful and useful than that which they had met to celebrate.

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We were glad to see such a good attendance in response to the invitation to visit the Engineering and Machinery Exhibition at Olympia on Thursday, 26th September.

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Under the guidance of several members of the Honorary Advisory Council a couple of hours were spent inspecting selected exhibits.

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Not only were members passed in free, through the kindness of the Organising Managers; but they received gratuitous professional lectures at the various stands. To hear a recognised engineering expert cross-examine an exhibitor and draw out for the benefit of ourselves the pros and cons of the particular piece of machinery under inspection was indeed a treat. One experienced the excitement of a patent fight in a law court without being involved in the costs.

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At the hour of 5.30 p.m., with the punctuality that characterises the "Juniors," the party assembled in one of the rooms near the entrance, where Sir Alexander B. W. Kennedy, as President of the Exhibition, welcomed them.

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What an interest Sir Alexander still takes in us after all the years which have passed since we listened to his address in the old Hawkstone Hall, near famous "Maudslay's." His kind

smile as he shook hands with us seemed to say, "here you are again, keeping yourselves posted up in the latest things in engineering. I am happy to be amongst you."

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Afternoon tea and cigarettes followed, on the considerate call of our Member Mr. Geo. B. Woodruff, the nice taste and judgment which he displayed in the presentation of both being quite in accordance with the best traditions of the Institution.

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A few short cordial speeches in the proposing of votes of thanks to each of those who had taken a part in the reception of the members, and replies thereto, with a little inspiriting homily by Mr. Arthur Ross *pere* thrown in by way of an extra, and we were again soon investigating, this time, each on his own account, some more of the devices of the mechanical engineers' art with which the Exhibition abounds.

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The lecture in the evening upon "Deep Sea Diving and Caisson Work" was most interesting. Given by a medical man —Dr. Leonard Hill—who had actually subjected himself to the effects of compressed air in an iron vessel and in actual diving, and had also made experiments upon anæsthetised animals, the information was "first hand."

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Illustrated by experimental apparatus and lantern slides, his remarks were easily understood. A diver in a Siebe Gorman dress and helmet was in attendance, and a demonstration was given with the Fleuss foul air and smoke dress in a glass panelled case filled with dense smoke.

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The pleasure of the lecture was enhanced by the circumstance of Col. Sir Edward Raban occupying the chair, and so happily recalling to us as he did the time of his being our President in 1902-3.

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Dr. Hele-Shaw's contribution to *The Journal* this month on "The Future of Aerial Navigation" appears most opportunely after the fine performance on the 5th October of "Nulli Secundus," or "Dirigible No. 1," by one or other of which names the new British military airship may become known. A voyage

from Aldershot to London at a speed of about twenty-four miles an hour, at a mean altitude of 750 feet and a maximum of 1,300 feet is its record, the total distance covered being fifty miles.

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Engineering considerations being largely involved in its construction and that of its machinery of propulsion and direction, indicate possibilities of distinction in a department of work to which hitherto the practical engineer has not applied himself very seriously.

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It is with deep regret we receive, just as we are going to press, the news of the sudden death in Paris of Mr. Basil Pym Ellis, partner in the firm of Messrs. John Aird and Sons, Honorary Member of our Institution.

ROYAL SANITARY INSTITUTE CONFERENCE AT DUBLIN.

REPORT OF THE INSTITUTION'S DELEGATE, PROFESSOR W. E. LILLY, D.SC. (MEMBER OF COUNCIL FOR IRELAND).

As the delegate representing the Junior Institution of Engineers, I attended the Conference of the Royal Sanitary Institute which was held at Dublin from 25th to 28th June last. The meetings of the different sections took place in Trinity College, and were well attended. The majority of the papers read dealt with subjects closely allied to sanitary science, and were not of great interest from the engineering point of view.

Sir Charles Cameron, in considering "Sanitary Administration in Ireland," dealt with the powers of the Local Government Board and the position of the various officers of health in relation thereto. Mr. P. C. Cowan, M.Inst.C.E., discussed "The Economic Housing of the Working Classes," and in the course of his remarks said that public opinion generally agreed with Goldsmith that:—

> "Ill fares the land, to hastening ills a prey
> Where wealth accumulates and men decay."

Mr. Cowan deplored the apathy shown by local authorities in the question of the housing of the working classes. Ways and

means were then referred to as to how it could be treated, and the costs of labourers' cottages were compared.

Other papers of the various sections were by Dr. S. Rideal on "Disinfection"; Sir John Moore on "Climatology"; Mr. W. Kaye-Parry on "The Requirements as to Sewage Disposal"; and Professor McWeeney on "The Rôle of Sanatoria." These papers are all in print and can be read in the current issue of the Journal of the Royal Sanitary Institute, a copy of which will be found in the Institution's Library.

The visit to the new main drainage outfall works was of interest. These works, with their connecting sewers, had been in course of construction for some years, and were recently opened. The method of treatment is by precipitation, the lime process being adopted. The pumping station and precipitation tanks and other parts of the works were thrown open for inspection. Visits were also paid to the Iveagh Trust Buildings, Messrs. Guinness's Brewery, and other places of interest.

The members and delegates were hospitably entertained by their Excellencies the Lord Lieutenant and the Countess of Aberdeen at a garden party at the Vice-regal Lodge, which was numerously attended, a brilliantly fine day contributing to the success of the function, and in the evening they were the guests of the Right Honourable the Lord Mayor at a smoking concert given at the Mansion House.

The Thirty-fifth Visit of the Twenty-sixth Session took place on Saturday afternoon, 7th September, 1907, at 3 p.m., to the Works of the Metropolitan Water Board at Hampton-on-Thames, through arrangements kindly made by the President, Mr. William B. Bryan, Chief Engineer to the Board, by whom the particulars below have also been furnished. The attendance was 52.

Mr. Walter J. Hunter, Assistant Engineer of the Western District (Member of the Institution), showed the visitors round, and at the conclusion afternoon tea was kindly provided by the President. The thanks of the Institution for the privileges which had been enjoyed in connection with the occasion, were expressed by the Chairman, Mr. Lewis H. Rugg, and Mr. Hunter replied.

The works on the north bank of the Thames comprise intakes,

reservoirs, filter beds and pumping machinery for the supply of the Western and Southern Districts.

Western District.—The West Middlesex portion consists solely of a pumping station. The pump wells are supplied by two 48-inch conduits from the Thames, and also by a 48-inch conduit from the Staines reservoirs. The water is pumped to subsidence reservoirs at Barnes and Barn Elms (Hammersmith) by the following engines:—

One horizontal compound high duty Worthington; H.P. 400; capacity, 24 million gallons per 24 hours.

Two triple expansion vertical high duty Worthingtons; H.P. 450 each; capacity, 16 million gallons per 24 hours.

On the Grand Junction Works there are two reservoirs; one for the storage of unfiltered water with a capacity of 45 million gallons, the other being a covered reservoir to hold 2½ million gallons of filtered water.

There are 13 filters having an area of 15¾ acres. Of these, Nos. 1 to 5 are supplied direct from the Thames, and the remainder by gravitation from the storage reservoir. After filtration, the water is pumped to the Country District and to reservoirs at Kew Bridge for Town District supply.

The engines are as follows:—

	Head ft.	Capacity per 24 hours.		Pumping performed.
1 compound condensing centrifugal...	16	11	mil. gals.	From river to filters.
1 pair compound condensing Riedler low lift*	22	14	do.	Do. and to subsidence reservoir.
1 do. do. high lift ...	150	14	do.	To Kew Bridge Works
1 triple expansion condensing Worthington	165	3½	do.	Do. and to Country District
1 do. do.	165	7	do.	
2 horizontal expansion condensing, with 3-throw pumps ...	17	10	do.	Partly from gravel beds, partly from river.
2 Cornish Bull	125	22	do.	To Kew Bridge.
1 do. do.	100			
1 "Davey" compound condensing ...	165	3	do.	To Country District.
1 pair compound condensing beam ...	165	8	do.	do.
1 triple expansion vertical ...	165	5	do.	do.

* The Riedler gear was detached from these engines some years ago.

Southern District.—At the Southwark and Vauxhall Works are three reservoirs for unfiltered water. The capacity of the two Stain Hill reservoirs being 304¼ million gallons, and of the Sunnyside reservoir, 83 millions.

There are 34 filters, with a total filtering area of 35¾ acres. The filtered water is pumped to service reservoirs at Nunhead, to

intercommunication works at Battersea, and also to reservoirs in the Lambeth section of the Southern District.

The engines are as follows:—

	Capacity per 24 hours.		Pumping performed.
2 single acting beam	10 mil. gals.		To lower reservoirs at Nunhead or the district.
1 pair direct acting compound inverted rotative	18	do.	To Nunhead or district.
1 do. do. geared ...	16	do.	Lifting water from Natural Filtration Works.
1 set of tri-compound inverted geared	16	do.	Do. do.
2 pairs single-acting high speed ...	20	do.	Lifting water from river to fill reservoir.
3 sets direct acting tri-compound inverted rotative	27	do.	To lower reservoirs at Nunhead or the district.
2 direct acting Cornish Bull ...	14	do.	
1 do. do.	9·8	do.	

The Thirty-sixth Visit of the Twenty-sixth Session took place on Thursday, 26th September, 1907, when an inspection was made of the Engineering and Machinery Exhibition at Olympia, on the invitation of the Organising Managers, Messrs. G. D. Smith and F. W. Bridges, the total attendance at afternoon and evening being 86.

Assembling at the entrance at 3.30 p.m., the members were met by Messrs. Smith and Bridges. Under the guidance of Dr. H. S. Hele-Shaw, F.R.S. (one of the patrons of the Exhibition) and Mr. John Bilbie, Mr. W. H. Cook, Mr. Thos. W. How and Capt. H. Riall Sankey, R.E. (Members of the Honorary Advisory Council), the features of special interest were examined. They were then received by Sir Alexander B. W. Kennedy, F.R.S., as President of the Exhibition.

After tea, to which the party were kindly invited by Mr. Geo. B. Woodruff (Member), Sir Alexander expressed the pleasure he felt at being present, and the thanks of the Institution to him, to Messrs. Smith and Bridges, and to Mr. Woodruff, were conveyed by Mr. Lewis H. Rugg (Chairman). Mr. Bridges and Mr. Woodruff having replied, the members' acknowledgments of the great assistance rendered by the gentlemen who had acted as guides were communicated by Mr. B. E. Dunbar Kilburn, and Dr. Hele-Shaw responded. Mr. Arthur Ross, Sen., also added a few words.

At 8 p.m. the members met in the Lecture Hall, when the chair was taken by Col. Sir Edward Raban, K.C.B. (Past-President

of the Institution). An illustrated lecture on "Deep Diving and Caisson Work" was delivered by Dr. Leonard E. Hill, M.B., F.R.S. Votes of thanks to the Lecturer, proposed by the Chairman and seconded by Mr. Rugg; and to the Chairman, proposed by Mr. A. W. Marshall, concluded the proceedings.

As indicating the character and scope of the Exhibition (open from September 19th to October 19th) the following may be quoted from the Introduction to the Catalogue:—

The present Exhibition occupies a far larger area than its predecessor, and although the heavy engineering trades are not as fully represented as could have been wished, in consequence of the continued activity in engineering circles generally, there is a marked increase in the number of such exhibits, and it is pleasing to note that a large proportion are British firms. Nearly 100 firms who were not exhibiting in 1906 are present, and this fact alone is sufficient to indicate that the present Exhibition contains an immense quantity of machinery not seen last year. To this may be added the fact that many of those who were represented last year are now introducing new machines of the latest designs in engineering appliances, so that the whole of the vast building teems with items of interest to all who are either directly or indirectly associated with the engineering industry.

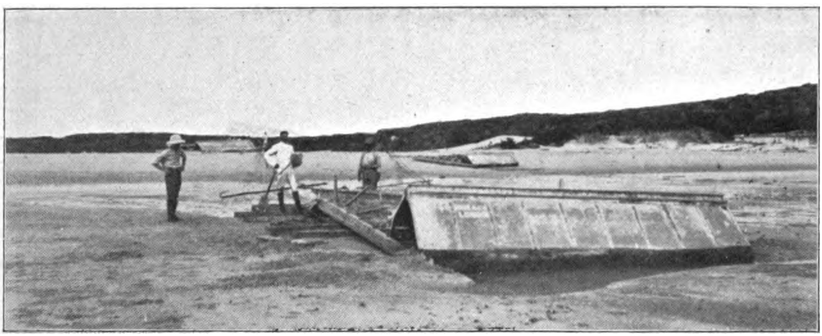
Mining appliances form a very important part of the present Exhibition, and visitors from the Colonies, or representatives of Colonial houses, will find much to assist in the development of the mineral wealth of the world.

The scope of the Exhibition is necessarily very wide, for so enormous have been the strides made in the mechanical arts of late years that mechanical engineering permeates every one of our national industries and their many branches. It is certainly not necessary to follow its development in detail, and it may be said at once that the industry is well and worthily represented in the present Exhibition and that buyers and users have the latest developments in engineering skill brought prominently before them.

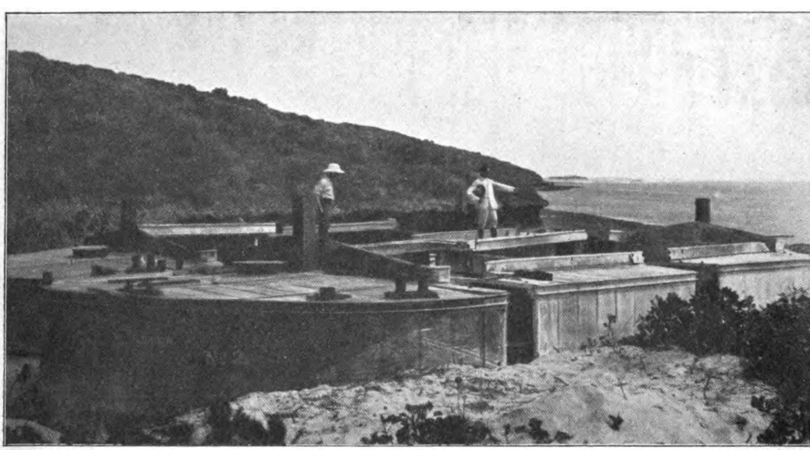
As the result of the last Exhibition, a grant of £500 was made to the funds of the various Benevolent Institutions connected with Engineering Associations, and it is hoped that the present Exhibition will be so successful as to enable an even larger sum to be available for the same purpose.

ERECTION OF LIGHTERS AT KISMAYU.

Launching the first Lighter.



Some of the Sunken Sections after being raised from the sand.



Two Lighters on Slipway ready for joining together after re-construction.

CORRESPONDENCE.

ERECTION OF LIGHTERS AT KISMAYU.

W. J. PENDLETON (Member) writes from Kismayu, British East Africa :—" I have been cutting to pieces and re-building the first four lighters for the Emperor Navigation, Ltd., that came out in sections and were wrecked on the island off Kismayu. They each had originally five sections of galvanised steel, but now have only four, the spare section in each case being used to make up the broken plates, the lighters, each built up of four sections, being quite big enough for our purpose on the river. They are each 70 feet long by 17 feet wide and 4 feet deep, with a draught of 2 feet. The four lighters thus reconstructed are all now finished, and in the water, and very glad I am, as may well be imagined, for with only native labour available the job was by no means an easy one. The natives had never seen such work done before and had to be instructed and closely watched throughout. The cutting up of the plates was the hardest part, as I had perforce to make all the chisels for these amateur ship-builders, and after they had hit their fingers once or twice in the usual manner they exhibited a profound disgust for the whole thing and did not want to work any more, but such difficulties of course had to be encountered and overcome. The launching was an awkward business, as the lighter had to be built on the level and got on to an inclined slipway afterwards."

[Mr. Pendleton sent a number of interesting photographs, including some showing the lighters in their wrecked condition on the island and as rebuilt. We have reproduced several of these as illustrating the nature of the work carried out.—Ed.]

THE WHITE NILE PROVINCE, SUDAN.

S. MAGNUS MACDONALD (Member), District Engineer for the White Nile Province, of the Public Works Department, Sudan Government, in July last wrote from Dueim, Sudan :—" This province lies immediately south of Khartoum, and consists of a strip of country averaging about forty or fifty miles in width on each bank of the White Nile, the whole district approximating to Ireland in size. The climate is delightful, and I have suffered no inconvenience from heat except for a day or two in March, but just now the rains are keeping the temperature quite low.

"My work can hardly be termed 'engineering' as, so far, it has consisted of buildings only; in Khartoum itself there has been a great deal of work done since the expedition, but, of course, not so much in out-stations. The central town of this province is El Dueim, and most of the work for the current year has been concentrated here. The most important job has been the construction of administrative offices for the Governor and his staff, and this building is now in use. The Governor's House has been built, and I have in hand a block of offices for my department, and one Rest House each for British and native officials, these latter being used by officers, &c., when passing through to other stations. All the buildings are of a similar type; a good sandstone is obtainable locally, and very fair bricks, too, and the walls are generally built with about three courses in stone and two in brick. The roofs are chiefly formed with rolled steel joists and jack-arches, finished with a suitable thickness of concrete, while the floors are either cement rendered or laid in cement tiles. As much verandah accommodation as possible is provided for each house, and they are mostly of the timber type.

"El Dueim has all the advantages of a river-side town, and there is always at least one steamer between this and Khartoum every week, but engineers inland have to transport what stores they require from the nearest point on the river by means of the much-maligned camel."

TO THE VICTORIA FALLS ON THE ZAMBEZI.

R. W. NEWMAN, of Grahamstown, writes:—Our Secretary, on hearing that I contemplated a trip to the Victoria Falls on the Zambezi, and knowing that I had already been to Niagara, promptly extorted a promise that I would write for *The Journal* something about the Victoria Falls "from an engineer's point of view." I have gone further, and given an outline of the whole trip from Grahamstown, because I thought it would enable many to form an idea of the extent of this huge country.

My eldest son, aged thirteen, accompanied me to Niagara and on this trip, and will no doubt correct me if I fall into any errors in the following account of our tour, as a junior (member or not) is nothing if not critical.

Starting from Grahamstown on 1st July, at 9 a.m., and going by the nearest direct route to the North via Alicedale, Cradock, and Nauwpoort, we crossed the Orange River into that Colony at 3 a.m. on 2nd July. Leaving Bloemfontein after breakfast, and reaching the Transvaal at about 6 p.m., we arrived at Johannesburg at 7.30 the same evening, for the last two hours passing many mines with the unceasing noise of their stamps extracting the precious metal from the rock, and the clang of cages as they came to the surface and dropped on the "keps" as they discharged further supplies of rock to the crushers. We thought of the Juniors who were superintending the operations with a watchful eye, and regretted that time did not admit of our leaving a card of good fellowship as we sped by.

A few days spent in Johannesburg, seeing mines, buildings, &c., and marvelling at the great city which has risen from the veldt in less than twenty-five years, and at Pretoria visiting the Houses of Parliament, the residence of the late President, the Zoo, &c., sped rapidly by.

On Monday, 8th July, at 9.30 a.m., we were steaming out of Johannesburg Station *en route* to Bulawayo *via* Klerksdorp, Potchefstroom, to Warrenton, where we joined the main line from Kimberley to Bulawayo, arriving at the latter place, after an uneventful journey of three days and two nights, at 8.30 p.m. As will be seen by the map we had to travel south to go north, but the engineer is at work, and no doubt the railway which runs from Johannesburg to Zeerust, and which was only opened to the latter place by Lord Selborne on 5th July, will shortly be extended a further thirty-four miles, and join the Bulawayo line at Lobatri, and later, probably the existing line from Pretoria to Pietersburg will be extended to Bulawayo.

Bulawayo, with its forty-four miles of streets, lit with electric light, fine buildings and suburbs, has been laid out on the American plan, with all streets at right angles, and will in time be built over, but at present its houses and shops alternate with vacant plots of land.

Leaving Bulawayo by motor early next morning, we proceeded to the Matopos, to see the Shangani monument erected to the memory of Alan Wilson and his brave men who fell in the Shangani Rebellion of 1893, and the grave, blasted out of the solid granite, of that great statesman to whom South Africa

owes so much, with the simple inscription above it: "Here lie the remains of Cecil John Rhodes." No date, no recorded flights of oratory or poetic utterances are there inscribed. He lived a simple life, his wonderful ability and energy being unsparingly devoted to the service of our Empire. Surely the memory of such a man can never fade. The scenery on our sixty mile ride to and from Bulawayo defies description; I can only say it was rugged nature at her best, untouched by the hand of man except where the park is being formed according to Rhodes' instructions, for the benefit of the people of Bulawayo for ever.

Joining the train on Friday morning, 12th July, for Victoria Falls, the day passed pleasantly away in conversation with a brother engineer from America, whom we found on board. We felt how different was our visit compared with Livingstone's in 1855, and thought how little he dreamed of a first-class saloon and dining car reaching the Falls within fifty years of his first visit—"and a free pass"—added my fortunate friend as he produced his to the ticket collector. Later, when we had dined and the attendant demanded 4s. 6d. (it was 3s. when we left the Cape) we smiled and thought that contractors (even refreshment contractors) are not altogether indispensable. At 6.30 next morning we were awakened by the announcement of that truly South African institution—"morning coffee." Having dressed and packed our luggage, along came the conductor with the intimation "Victoria Falls in five minutes, gentlemen," and looking out we saw the sun rising above the Falls shining through clouds of spray and faintly disclosing the semi-tropical plants in the forest around—a spectacle never to be forgotten.

Half-an-hour later, walking on to the hotel stoep which looks directly up the gorge below the Falls, we beheld the fine bridge with its 500 feet arch spanning it, and a few minutes later saw our train cross it, leaving Southern Rhodesia for North-West Rhodesia, on its way to Broken Hill, 375 miles further towards the centre of the dark continent, and present terminus of the railway. Five hours later we bade our American friend good-bye. He had "done" the Falls and was returning South.

Doubtless the first question suggested will be "How does Niagara compare with Victoria Falls"? It is a question to which one answer will not suffice, the conditions are so totally different. Niagara is in a populous manufacturing district.

At Victoria Falls, the hotel proprietor, a photographer, and a few railway employees are the only permanent residents. With regard to the height and length of the falls, Victoria Falls with its crest over a mile long is considerably the longer. It has a depth at the point where the waters converge below the falls of 357 feet, or 187 feet higher than Niagara. Niagara would not seem to vary in its discharge as much as Victoria Falls, but, as an American gentleman who had seen both expressed his feelings, "After Victoria Falls, Niagara is only a perspiration," and wiped his brow at the thought. To such an opinion so lucidly expressed, I can only bow and acquiesce.

The full length of Victoria Falls can never be seen except when little water is passing, owing to the spray rising and being carried over by the wind, the prevailing wind being to the west. To the ground on which the spray falls, resulting in its remaining permanently green, has appropriately been given the name of "the rain forest." In natural beauty Niagara's curved formation lends a graceful appearance which cannot be denied, but that is a small feature of beauty compared with the sub-tropical surroundings of the Victoria Falls, which give them an irresistible charm. It must have been with interest that engineers read Mr. Churchill's reply to Mr. Essex in the House of Commons on 13th May last, in which he said that one of the conditions required by the British South Africa Company in granting to the African Concession's Syndicate a seventy-five years' lease of the water power was that the Syndicate should undertake that none of its works to be carried out should destroy, disfigure, or interfere with the natural beauty and characteristics of the Victoria Falls and their surroundings.

To the engineer the questions naturally arise, when will Victoria Falls be harnessed? and where will the power be used? The man who would answer the former question in the face of the extraordinary developments which South Africa has seen in the last twenty-five years would be bold, and in reply to the latter, it may be said that the only place at present appears to be the Rand at Johannesburg, but this is 600 miles away, over an uninhabited country, liable to semi-tropical electrical discharges and atmospheric disturbances which would make the early Deptford engineers envious. Briefly, it is estimated that 450,000 H.P. is available, and the Rand now uses 150,000 H.P.,

costing £30 per H.P. per annum. At Niagara the cost per H.P. at Buffalo, thirty miles away, is stated to be £25 11s. 0d. per H.P. per annum, so that it would seem that other and nearer centres of distribution will have to be developed if the scheme is to be financially successful. I give the above figures from a reliable source.

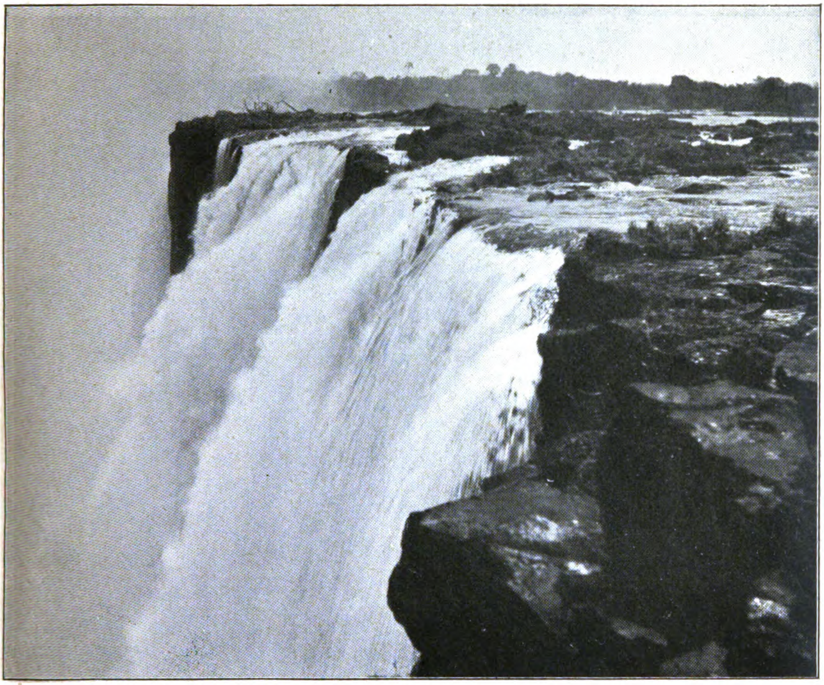
As to the works required there would not appear to be any insuperable difficulty, but there is one which is not shared by Niagara. I have referred above to the mist rising from the Falls, which looks in the early morning like the exhaust from an electric light station where the condensers have failed, and which is also blowing down its boilers after a hard night's run, but which means "fever," a danger which all engineers who work in tropical countries have to face.

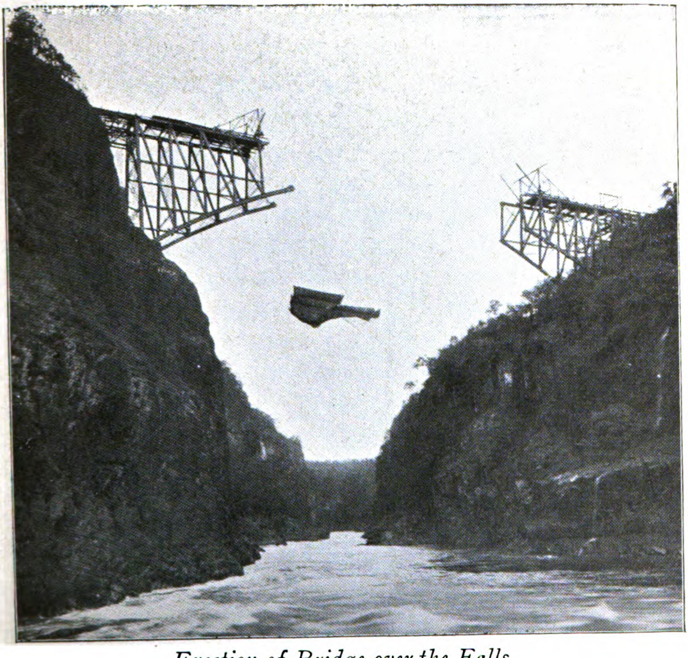
The development of such a source of power will of course eventually result in more work for engineers, but whether they will be Juniors of to-day or Juniors whose faces would remind us of Juniors we have known, time alone can prove. The Victoria Falls is one of the great sources of power in nature which will yet be directed for the use and convenience of man.

I mentioned above that the bridge crosses the gorge. Niagara has its many bridges, but the bridge at Victoria Falls has peculiarities of its own. The rail level is 350 feet above low water in the gorge, and as works in progress always appeal to engineers more than do completed structures, I enclose a photograph taken during the early stages of construction. To better understand the situation of the bridge, one has to bear in mind that though the falls are over a mile long the gorge or outlet for the water is only about 500 feet wide. There appears to be a huge chasm in the ground with little or no variation of surface level. The level of the water in the gorge varies 50 feet in level with the varying discharge over the Falls. It is over this gorge that the bridge is carried, a handsome structure built and erected by the Cleveland Bridge and Engineering Company, of Darlington, to the designs of Sir Douglas Fox and Sir Chas. Metcalfe.

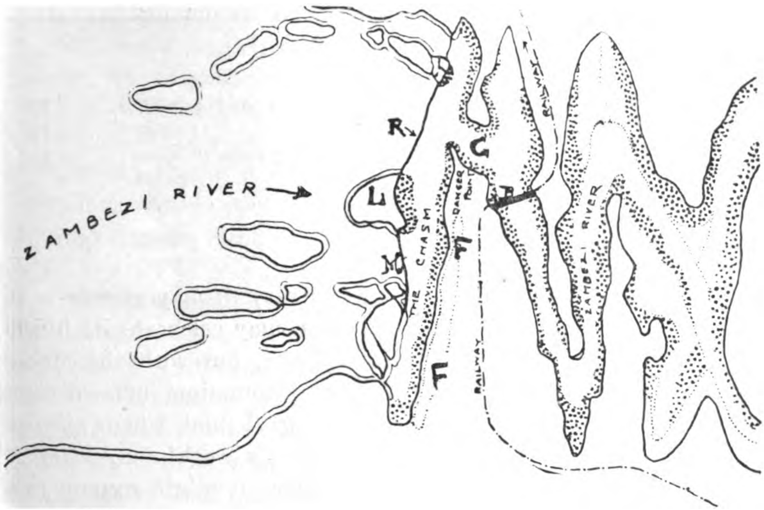
The Juniors at home having set an excellent example in drawing together engineers and architects, in emulation thereof we made friends with an architect from the Public Works Department of North-West Rhodesia and his companion, whom it proved was closely related to one of the leading Westminster

VICTORIA FALLS ON THE ZAMBEZI.





Erection of Bridge over the Falls.



B *Victoria Bridge.*
FF *Rain Forest.*
G *Gorge.*
L *Livingstone Island.*
M *Main Fall.*
R *Rainbow Fall.*

engineers, and who had himself started his career in the profession, though leaving it later, and we decided to celebrate the occasion by making up a picnic party for the following day, when, paddled by four natives, we made our way in a canoe to Kandahar Island, so named by Lord Roberts during his visit in 1904. As we lay on the ground discussing our lunch we were interrupted by the sneeze of a hippopotamus, and we were advised to look for a safe retreat up the nearest tree, but after a few more appearances at a distance of fifty yards he retired. We made our return along the course of the Zambezi Regatta of 1905, and early on 15th July boarded the train for Kimberley, arriving there at breakfast time on the 18th, having been three days and three nights in the train, passing Mafeking and Vryburg en route.

Two days in Kimberley to see the diamond mines and other interesting sights sufficed, and on the 20th we left Kimberley, arriving at Cape Town on the evening of the 21st.

To make clear the enormous distances and to show the speed (sic) of the trains, I append a table giving the mileage and times. The fares are also added, and are of course the ordinary, but

concession, privilege and excursion tickets are obtainable at much reduced rates.

	Miles.	Time.	Fares.		
Grahamstown to Johannesburg ...	676	1 day 10½ hours	6	11	5
Johannesburg to Warrenton ...	264	13 hours	2	13	8
Warrenton to Victoria Falls (return) ...	1341	5 days 16 hours	19	19	7
Warrenton to Kimberley ...	44	3 hours	0	9	2
Kimberley to Cape Town ...	647	1 day 6½ hours	6	6	2
	2972	9 days 1 hour	£36	0	0

To those who have followed our itinerary, it may appear to be a far cry to suggest that the Institution *may* celebrate its fiftieth anniversary by meeting at Victoria Falls, but with the strides which engineers have made in modern locomotion such an event may be possible and even probable, though I think I hear some of the members say "a summer excursion is a week's hard work." No doubt, however, on such an occasion, it might extend to a month. I can only express the assurance that though all may not be there, the Juniors who do go will never regret the trip if they enjoy it as much as we did.

NOTES AND QUERIES.

LUBRICATION OF GAS ENGINES.

R. MARSHALL (Member) replying to the query at page 537 of the recently completed Vol. XVII. of *The Journal* writes:—With reference to the clarification of castor oil, any attempt to do this by chemical methods would probably result in loss of viscosity, and would also require a good deal of care, but bleaching by means of sun exposure in glass vessels might be tried. What is the objection to the dark brown colour? As regards the lamp black, this might be advantageous rather than an evil from a lubricating point of view. If the cylinder oil is a mineral oil it will not combine with the castor oil, and of course can easily be separated from it by means of one of the various types of mechanical filters. How would a mineral oil do as a substitute for the castor oil; say a Russian oil 911 gravity with a viscosity of 460 at 70 degrees F.? There does not appear to be a book dealing with refining solely, but I would suggest as a practical treatise "Lubricating Oils, Fats and Greases," by Hurst, published by Scott, Greenwood and Co., London.

MR. L. F. de PEYRECAVE (Member) writes to the Editor:—Replying, in accordance with your request, to Mr. Hewitt's question in the August number of *The Journal*, I do not think it will be necessary to resort to "bleaching," properly so-called, which is liable to entail prohibitive expense; but if Mr. Hewitt has not already tried the following method used in refining, I think he would find it worth while to do so, after separating off the cylinder oil. (1) Simply raise the temperature of the oil to about 40 degrees C., and allow it to cool and stand for a time. (2) Blow a jet of steam through the oil by means of a fine rose jet. (3) Mix a small quantity (to the extent of say one per cent.) of concentrated zinc chloride solution (sp. gr. 1·85) and agitate the mixture well, and then give it time to settle, when the impurities should be deposited with most of the chloride, any that may still remain being removed by agitation with water. (4) Place the oil in a lead-lined boiler, and introduce a tube containing rather less than one per cent. of liquid sulphur dioxide into the oil, and then heat the whole to about 35 degrees C. to 40 degrees C., and allow to cool. Then wash the oil thoroughly with warm water, and filter it. Still better results are sometimes obtained by treating the oil with zinc chloride before the sulphur dioxide process. I have mentioned the foregoing methods approximately in their order of simplicity. There are of course many other processes, but they are mostly liable to injure the lubricating qualities of the oil, whereas the four mentioned above should be quite free from any such ill effects. I would suggest trying experiments with each of the four methods on small quantities of oil.

DOUBLE CURRENT GENERATORS:

H. GROOME (Member) of Ryde, writes:—Can any member give me information as to the behaviour of double current dynamos when working on combined load. By "double current," I mean a D.C. machine say 100 KW. capacity, giving 500 volts D.C., and fitted with slip rings to supply A.C. current at 50 cycles. I believe they possess some objectionable sparking troubles when working on the combined load, which prohibits their being 'oaded to the full capacity. I should like this last point confirmed.

A MEMBER writes in reply to the above enquiry: "There should be no difficuly in getting a satisfactory double current

generator of 100 KW., 500 volt C.C., giving a resultant A.C. voltage at 50 cycles, although, as far as the writer is aware, no such machines are in operation, except for test bed purposes. Mr. Groome does not state whether a single or three-phase current is required; the latter would of course be the better machine, and if the speed were kept low, say 600 R.P.M., no commutation troubles need be feared. There are several double current generators, but designed for 25 cycles A.C. supply, installed in various works, and the writer can assure Mr. Groome that the commutation of some of the plants under all possible conditions of load, leaves nothing to be desired. Very serious trouble was experienced with double current generators of German design some time ago, and it is possible that Mr. Groome may have heard of these difficulties, and so have been needlessly disturbed.

The Junior Institution of Engineers.

Report of the Council for the year ended 30th September, 1907.

For presentation at the Annual General Meeting on 18th October.

The Council have pleasure in presenting the following as their Report for the year ended 30th September, 1907.

Membership.—At that date the total number of names on the Register was 967 as compared with 908, the corresponding number for the previous year, an increase of 59.

The usual analysis of the Membership is given below:—

Class of Membership.	25th Sn. 1905-6.	Twenty-Sixth Session, 1906-7.			
	At end.	Elected and transferred.	Resigned, transferred &c.	At end.	Increase.
Honorary Officers	**38**	1	1	**38**	—
Honorary Members	**43**	2	—	**45**	2
Members	**792**	75	38	**829**	37
Associates	**35**	24	4	**55**	20
Totals	**908**	102	43	**967**	59

The elections of the year under review include that of Sir John Aird, Bart., as Vice-President, and of Mr. Malcolm Aird and Mr. Basil Pym Ellis as Honorary Members.

Meetings.—Eight meetings have been held during the Session, at which the average attendance has been 118, the Papers, &c., read and discussed being as given in the list below.

With the object of facilitating the attendance of as many members as possible, the Council introduced at the commencement of the Session the innovation of holding the meetings on a different day of the week each month, instead of on the first

Friday, as had been the custom for some years previously. They believe that the arrangement is greatly appreciated, as enabling many to attend all the meetings, who would otherwise be obliged to absent themselves from some of them.

Opportunity for social intercourse over a cup of tea or coffee at the conclusion of the meetings has also been inaugurated during the past Session, forming an agreeable termination to the evening's proceedings.

The members of the Discussion Section of the Architectural Association were invited to assist in the discussion of the Paper on "The Structural Design of Engineering Factories," as being a subject in which both professions were interested, and an excellent combined meeting took place. An invitation for another similar meeting to be held on the 12th February next at the House of the Architectural Association has been accepted by the Council, when a Paper entitled: "Some suggestions as to how the Architect and Engineer may combine," by Mr. Percy J. Waldram, is to be read and discussed.

To the February meeting the members of the Junior Meetings of the Surveyors' Institution were invited, means being thereby afforded for representatives of yet another kindred profession to exchange views with those of members of the Institution on questions of common interest, the subject discussed being "The Relation of Surveying to Engineering."

Programme of Meetings during 26th Session, 1906-1907.

1906.

Oct. 16th. Annual General Meeting of the Institution and of the Benevolent Fund, followed by Paper on "The Protection of Inventions," by MR. B. E. DUNBAR KILBURN, M.A. (Camb.).

Nov. 2nd. Presidential Address by MR. WILLIAM B. BRYAN, M.Inst.C.E., on "Water Supply."

Dec. 3rd. "The Structural Design of Engineering Factories," by MR. ADAM HUNTER, Assoc.M.Inst.C.E.

1907.

Jan. 16th. "Stream Lines and their Application to Engineering Purposes," by DR. H. S. HELE-SHAW, F.R.S.

Feb. 14th. "The Timbering of Excavations," by MR. CHAS. W. PETTIT, A.M.I.Mech.E.

Mar. 11th. "Printing Machinery," by MR. W. LYALL POWRIE, A.M.I.Mech.E.

April 9th. "The Relation of Surveying to Engineering," by MR. GEO. P. KNOWLES, Assoc.M.Inst.C.E.

May 8th. "The Theory of the Steam Turbine," by Mr. H. M. MARTIN, Wh.Sc., and MR. R. H. PARSONS, Assoc. M.Inst.C.E.

Institution Medal.—The Adjudication Committee, having considered the Papers competing for the Institution Medal of the Twenty-sixth Session, have declared their award in favour of the Paper on "The Structural Design of Engineering Factories." The Medal will accordingly be presented to Mr. Adam Hunter at the November meeting of the new Session as usual.

It should be added that as Mr. H. M. Martin, who collaborated with Mr. R. H. Parsons in the preparation of the Paper on "The Theory of the Steam Turbine," was not a member of the Institution, that Paper was precluded under the Rules of the Institution from competing.

Visits to Works, &c.—Realising how greatly the engineer may benefit from visiting works in operation, from the inspection of industrial processes, and the like, the Council have during the past year arranged no fewer than thirty-six visits, the list of which is given below. The Institution is much indebted to the respective authorities and officials for their kindness in granting permission for the visits to be made, and for the facilities and hospitality which have been enjoyed.

The average attendance at the visits in the metropolitan area has been 81; the attendance at the Summer Visit to Scotland was 57.

In preparing the programme of the latter, Mr. Adam Hunter, as Hon. Local Secretary, rendered great service, and was ably assisted by Mr. A. Knight Croad. The Council have passed a special resolution expressing the thanks of the Institution for the cordiality of the reception which was experienced, and a copy has been communicated to all who took part in making the members so welcome.

The very hospitable civic reception at the Municipal Buildings on the opening day with the Lord Provost of Glasgow presiding, attended by the Magistrates of the city, should be especially mentioned.

Visits to Works, &c., during the Session 1906-1907.

1906.

Oct. 13th. The Engineering and Machinery Exhibition, 1906, at Olympia.

Nov. 17th. The London County Council's Electricity Generating Station, Greenwich.

Nov. 30th. The Great Northern, Brompton and Piccadilly Railway.

Dec. 8th. Honor Oak Reservoir Works of the Metropolitan Water Board.

1907.

Jan. 19th. The Royal Naval College, Greenwich.

Feb. 23rd. The Rotherhithe Tunnel Works of the London County Council.

Mar. 23rd. The Fortis Green Reservoir Works of the Metropolitan Board.

April 17th. Messrs. Cassell and Company's Printing Works, London.

May 18th. The Mathematical Instrument Works of Messrs. W. F. Stanley and Co.; and the Stanley Technical Trade Schools at West Norwood.

June 8th. The Photographic Works of Messrs. Kodak, Ltd.; Harrow School; Harrow Church; and the Electricity Works of the Harrow Electric Light and Power Company.

June 13th. The Charing Cross, Euston and Hampstead Railway.

June 29th to July 6th. Summer Visit to Scotland:—

Boiler Works of Messrs. Babcock and Wilcox.

Clyde Navigation Trustees' Works.

Constructional Engineering Works of Messrs. Sir William Arrol and Co.

Edinburgh, University of, Engineering Laboratories.

Fairfield Shipbuilding and Engineering Company's Works.

The Forth Bridge.

Lanarkshire Steel Company's Works.

Naval Construction Works of Messrs. William Beardmore and Co.

Newcomen Engine at Farme Colliery.

North British Locomotive Company's Works.

Range Finder Works of Messrs. Barr and Stroud.

Sewage Purification Works of the Glasgow Corporation at Dalmarnock.

Sewage Purification Works of the Glasgow Corporation at Dalmuir.

Shipbuilding and Engineering Works of Messrs. John Brown and Company, Clydebank.
The Singer Manufacturing Company's Works, Clydebank.
Tube Works of Messrs. Stewart and Lloyd.
Yarrow and Company's Messrs., New Shipbuilding and Marine Engineering Works at Scotstoun.

July 20th. The Tilbury Docks; and R.M.S. "Oruba" of the Orient Line.

Sept. 7th. Hampton Pumping Stations of the Metropolitan Water Board.

Sept. 26th. Engineering and Machinery Exhibition, 1907, at Olympia.

The Journal.—The twelve monthly parts of *The Journal* which have been published during the year contain all the Papers read at the meetings, and in addition one on "Some Examples of Bridge Erecting in South Africa," contributed by Mr. H. G. Dempster, of Richmond, Natal, who will be remembered by some of the older members as the author of the Paper on "Suspension Bridges," with description of the Doyang River Bridge, Assam, which was awarded the Institution Premium of the Eleventh Session, 1891-2.

The Journal also contains reports of the visits made in the metropolitan district and elsewhere; as also numerous articles on topics of engineering moment and other interesting matter. For the assistance and support accorded them in the production of Volume XVII., consisting of 616 pages—the largest volume yet issued—the Publications Committee desire to express their cordial acknowledgments.

Conversazione.—Guided by the views which had been ascertained from the members, the Council decided that the Annual Conversazione should be arranged differently to those of previous years. It accordingly took place at the Caxton Hall, Westminster, on Wednesday, 13th March, the President and Mrs. Bryan, the Chairman and Mrs. Rugg, receiving the guests. A concert, dance, and whist drive followed. The Committee entrusted with the details of the occasion and the Stewards, all of whom were most indefatigable throughout the evening, are to be warmly congratulated on the great success which attended the function.

Anniversary Dinner.—The President, Mr. William B. Bryan, occupied the Chair at the Institution's Twenty-third Anniversary

Dinner, which was held at the Hotel Cecil on Saturday evening, the 9th February, 133 members and guests being present. The Council would here record the sense of their appreciation of the great interest in the affairs of the Institution which Mr. Bryan has shown by his attendance at various gatherings of the members, and in arranging several important visits; by his contributions through which the bank balances of the Institution, and of its Benevolent Fund, have been considerably augmented; and in other ways.

The guests who accepted invitations to the Dinner (although several were at the last prevented by unforeseen circumstances from being present) were:—The Rt. Hon. Lord Shuttleworth, P.C. (Chairman of the Royal Commission on Canals and Waterways); the Rt. Hon. Lord Farrer (Member of the Commission); Sir R. Melvill Beachcroft, L.C.C. (Chairman of the Metropolitan Water Board); Mr. E. B. Barnard, M.A., M.P. (Chairman of the Works and Stores Committee of the Metropolitan Water Board); Mr. A. B. Pilling (Clerk to the Metropolitan Water Board); Sir A. B. W. Kennedy, LL.D., F.R.S. (President of the Institution of Civil Engineers); Mr. Chas. Hunt, M.Inst.C.E. (President of the Institution of Gas Engineers); Dr. R. T. Glazebrook, F.R.S. (President of the Institution of Electrical Engineers); Mr. George Langridge (President of the Surveyors' Institution); Mr. Dugald Clerk (President of the Society of British Gas Industries); Mr. B. Alfred Raworth (Joint Editor of "Engineering"); Mr. T. E. Gatehouse, M.I.Mech.E., and Dr. H. S. Hele-Shaw, F.R.S. (Hon. Members).

Royal Sanitary Institute.—The Council accepted an invitation for the representation of the Institution at the Conference of the Royal Sanitary Institute, held at Dublin from 25th to 29th June. Professor W. E. Lilly kindly undertook the duties of delegate, and his report on the proceedings is to appear in the October number of *The Journal.*

Engineering and Machinery Exhibition.—The Institution represented on the Honorary Advisory Council by its Chairman and Secretary, has assisted in the promotion of the Engineering and Machinery Exhibition (1907) at Olympia, which was opened on the 19th September by Sir Alexander B. W. Kennedy, and was visited by the members on the 26th September, when, as President of the Exhibition, Sir Alexander received them.

Library.—The Hon. Librarian, Mr. H. T. Gould, has during the past year been devoting himself to a thorough scrutiny of the contents of the Library, the limited accommodation available rendering it necessary that those books only which are really of value for members' reference should be retained. At his own expense Mr. Gould is also having compiled a new catalogue on the Dewey system, the card index file for which has been presented by Mr. F. R. Durham, who has in addition made a donation to the Library Fund for the purchase of new books. Mr. Henry Cook and Mr. C. A. Spon have also kindly contributed to this Fund, the titles of the volumes procured thereby having been announced in *The Journal.*

To the Councils of the Engineering Societies who present copies of their proceedings; to the publishers of the various technical journals placed on the Reading Room table; to the other donors of the gifts to the Library, which have been announced in *The Journal* during the year; and to the above-named members, the cordial thanks of the Institution are due.

Members at Coventry.—It is pleasing to note that, acting on the suggestion of Mr. H. H. Thorne, and at his invitation, members residing at Coventry have held informal meetings at his house from month to month, for the reading and discussion of the Papers brought before the Institution at the Ordinary Meetings in London. They also formed a special party for attending the visit to the Rotherhithe Tunnel Works. The excellent example thus initiated by the Coventry members might well be followed by those in other districts, and lead to the establishment eventually of local sections, provision for which has been made in No. 72 of the Institution's Articles of Association which is as follows:—

> "The Council may at their discretion upon receipt of a request to that effect from what the Council may consider a sufficient number of Honorary Members, Members or Associates, resident in any district at home or abroad, create a Local Section of the Institution in such district."

Benevolent Fund.—The Committee of Management of the Institution's Benevolent Fund have to report that from the date of its establishment on the 25th June, 1906, to the 30th September, 1907, the end of the financial year, the amount of £123 7s. 3d. has been contributed; £40 13s. 9d. being derived from subscriptions, and £82 13s. 6d. from donations.

Special reference should be made to the donations of the President; of Messrs. Bridges and Smith (part proceeds of the Engineering and Machinery Exhibition, 1906); and of Mr. Kilburn. Mainly by means of these the Committee have been enabled to invest the amount of £100 in Consolidated 4 per cent. Debenture Stock of the Barnet District Gas and Water Company, in the names of Mr. Adam Hunter, Mr. Percival Marshall and Mr. Fred. S. Pilling, who were at the first Annual General Meeting held on the 16th October, 1906, appointed Trustees to the Fund.

A copy of the accounts, duly audited, is appended, as also the list of contributors, from which it will be seen that the subscribers number only 93, although the membership of the Institution is 967. The Committee venture the hope that with the commencement of a new Session, the number will be considerably increased. They are anxious that every member should be identified with this good work; and desire to say that the smallest contributions to the Fund will be gratefully welcomed.

In accordance with Rule II. two members of the Committee now retire. They are Mr. Geo. H. Hughes (of the Council of the Institution), and Mr. D. N. Hunt. To serve in their place the Committee have nominated for election respectively Mr. J. Wylie Nisbet and Mr. Geo. T. Bullock.

Accounts.—The usual financial statement for the year will be found appended, regularly certified by the Chartered Accountants, Messrs. W. B. Keen and Co., and the Honorary Auditors, Mr. L. M. G. Ferreira and Mr. H. Norman Gray, who have also submitted to the Council through the Finance Committee as usual periodical reports relating to each quarter.

The list of ordinary donations received during the year is as follows:—

		£	s.	d.
William B. Bryan (*President*)	...	15	15	0
Archibald Denny (*Past-President*)	...	1	1	0
F. W. Sanderson (*Vice-President*)	...	1	1	0
F. W. Dunn (*Hon. Member*)	...	0	10	6
D. A. Low (*Hon. Member*)	...	1	1	0
H. M. Rounthwaite (*Hon. Member*)		1	1	0
		£20	9	6

BENEVOLENT FUND OF

The Junior Institution of Engineers.

Subscriptions received from the establishment of the Fund, 25th June, 1906, to 30th September, 1907.

	£	s.	d.
Ablett, N. L. ...	0	5	0
Anderson, W. F. ...	0	5	0
Anonymous ...	1	1	0
Arding, G. F. ...	0	5	0
Avis, P. S.... ...	0	5	0
Baker, R.	0	10	0
Barnicoat, W. J. ...	0	5	0
Benyon, G. A. ...	0	5	0
Bingham, A. ...	0	5	0
Boot, J. N. ...	0	5	0
Bowtell, W. J. ...	0	10	0
Bromley, H. E. ...	0	5	0
Bullock, G. T. ...	0	5	0
Calder, Hugh ...	0	5	0
Canning, George ...	0	7	6
Carley, G. C. ...	0	10	0
Chabot, C. B. ...	0	5	0
Clift, G. E. ...	0	5	0
Cooke, S. V. ...	1	0	0
Cooper, W. J. ...	0	5	0
Crabb, H. G. ...	0	5	0
De Ritter, W. H. ...	1	1	0
Dunn, W. T. ...	0	5	0
Durham, F. R. ...	1	1	0
Eade, E.	0	10	0
English, J. W. ...	1	1	0
Evans, T. D. ...	0	5	0
Flack, Albert ...	0	10	6
Flack, Henry ...	0	10	6
Freeman, Ralph ...	0	10	0
Gentry, George ...	0	7	6
Goffe, Edward ...	0	5	0
Gould, H. T. ...	0	5	0
Gray, H. Norman ...	0	5	0
Carried forward	£14	10	0

	£	s.	d.
Brought forward	14	10	0
Gray, Kenneth ...	0	10	6
Groome, Harold ...	0	5	0
Hughes, Geo. H. ...	0	5	0
Hunt, D. N. ...	0	5	0
Hunter, Adam ...	0	5	0
Jackson, G. E. ...	0	5	0
Jacob, G. S. ...	0	7	3
Johnston, J. W. ...	0	5	0
Kilburn, B. E. D. ...	1	1	0
King, B. T. ...	1	1	0
King, Ernest ...	0	5	0
Knowles, Geo. P. ...	0	10	6
Lindley, F. E. ...	0	5	0
Macpherson, W. D.	0	5	0
Marshall, A. W. ...	0	5	0
Marshall, Percival ...	0	5	0
Marshall, Reginald	0	10	0
Matthews, Alfred ...	0	5	0
Milburn, G. O. ...	0	5	0
Miller, G. P. ...	0	5	0
Mules, R. J. ...	0	10	6
Nisbet, J. Wylie ...	0	5	0
Oswald, James ...	0	5	0
Parsons, R. H. ...	0	10	0
Paterson, William ...	1	1	0
Pearson, J. H. ...	0	5	0
Pettit, Chas. W. ...	0	5	0
Pfenninger, R. W. ...	0	5	0
Philpot, H. P. ...	0	10	0
Pilling, Fred S. ...	0	10	6
Porter, E. W. ...	0	10	0
Puddephatt, E. O. ...	0	5	0
Pugh, L. W. ...	0	5	0
Carried forward	£27	7	3

BENEVOLENT FUND.

SUBSCRIPTIONS—*Continued.*

	£	s.	d.
Brought forward	27	7	3
Raworth, J. E. ...	0	10	6
Rickie, J. H. ...	0	5	0
Rickwood, H. C. ...	0	5	0
Robus, Geo. H. ...	0	10	0
Ross, Arthur ...	0	10	0
Ross, James W. ...	1	1	0
Rugg, L. H. ...	1	1	0
Sells, C. de G. ...	1	1	0
Sims, H. C. ...	0	10	0
Smith, Chas. H. ...	0	10	0
Smith, Montague H.	0	10	6
Stanley, A. H. ...	0	10	0
Stevens, W. H. ...	0	5	0
Talboys, F. P. ...	0	5	0
Taylor, J. M. ...	0	5	0
Taylor, W. F. ...	0	5	0
Tennant, W. J. ...	1	11	6
Trevenen, E. ...	1	1	0
Trevett, B. ...	0	10	0
Walley, Thomas ...	0	5	0
Walter, G. L. ...	0	5	0
Wawn, C. J. ...	0	5	0
Way, A. G. ...	0	5	0
Winlo, R. Canning...	0	10	0
Yarrow, Harold E. ...	0	5	0
Young, Percy L. ...	0	5	0
Total Amount of Subscriptions	£40	13	9

DONATIONS

Received from the establishment of the Fund 25th June, 1906, to 30th September, 1907.

	£	s.	d.
Allingham, G. C. ...	1	1	0
Anonymous ...	5	0	0
Anonymous ...	0	5	0
Bryan, W. B. ...	15	15	0
Bullock, G. T. ...	0	1	0
Calder, Hugh ...	0	5	0
Cole, W. C. ...	0	2	6
Curry, A. E. ...	0	4	0
Durham, F. R. ...	0	5	0
Goffe, Edward ...	1	1	0
Gould, H. T. ...	0	1	0
Hickling, H. C. ...	1	4	0
Hulme, C. T. ...	0	2	6
Hunter, Adam ...	0	1	6
Kilburn, B. E. D. ...	5	5	0
Lupton, H. ...	0	2	6
Marshall, Percival ...	0	2	0
Morris, John T. ...	0	5	0
Oswald, James ...	0	1	0
Pearson, J. H. ...	0	10	6
Pettit, Chas. W. ...	0	1	0
Peyrecave, L. F. ...	0	10	0
Smith and Bridges ...	50	0	0
Stevens, W. H. ...	0	5	0
Wawn, C. J. ...	0	3	0
	£82	13	6

Future Arrangements.—The Council have every reason for anticipating that the Session now being entered upon will be one of the most notable in the history of the Institution. M. Gustave Canet's acceptance of the presidency; the interest he is already showing in the arrangements for his year of office; the resulting possibility of the extension of the Institution's area of influence in directions hitherto not contemplated; and the attainment of the numerical strength of the membership to 1,000, may be referred to in this connection.

It may also be added that M. Canet, in sending to Glasgow a message of good wishes for the success of the Summer Meeting in Scotland, expressed the hope that the meeting of 1908 would be in Paris; and furthermore, hearing that the Council were about to consider a proposal for the establishment of a Building Fund, that he has very generously contributed the handsome sum of £100 to inaugurate it.

The Junior Institution of

BALANCE SHEET,

LIABILITIES.

				£	s.	d.	£	s.	d.
To Subscriptions for year 1907-8—paid in advance							32	15	6
,, *Candidates for Membership*—Entrance Fees paid							7	7	0
,, *Accountants' Charges*							8	8	0
,, *Institution Medal of 26th Session*							1	1	0
,, *Binding Journals*:									
Cash received in advance from Members for binding Vol. XVII.							0	2	9
,, *Capital Account*—									
Compounding Fees—									
As at 30th September, 1906 ...				88	10	0			
Entrance Fees—									
As at 30th September, 1906 ...	232	18	0						
Add: Received during year ...	70	7	0						
				303	5	0			
Donations—									
As at 30th September, 1906 ...	20	15	6						
Add: Received during year ...	120	9	6						
				141	5	0			
							533	0	0
,, *Income and Expenditure Account*—									
As at 30th September, 1906				492	6	2			
Add: Balance for year to 30th Sept., 1907...				89	17	7			
							582	3	9
							£1,164	18	0

We certify that all our requirements as Auditors have been complied with. We have examined the above Balance Sheet and accompanying Income and Expenditure Account with the Books and Vouchers of the Institution, and in our

We have verified the Investments and Cash at Bank.

(Signed) W. B. Keen and Co., *Chartered Accountants*, 9th October, 1907.
23 Queen Victoria Street, E.C.,

L. M. G. Ferreira
H. Norman Gray } *Hon. Auditors.*

Engineers (Incorporated).

30th SEPT., 1907.

ASSETS.

	£ s. d.	£ s. d.
By *Office Furniture*—		
As per last Account	100 14 8	
Less: Depreciation	10 1 6	
		90 13 2
,, *Subscriptions* in arrear—Estimated value ...		130 0 0
,, *Debtors* for Advertisements :—		
Vol. XVII.		55 17 6
,, *Membership Certificates*		5 5 0
,, *Membership Badges*		1 17 0
,, *Reading Cases*		1 13 11
,, *Investments*—		
£294 15s. 10d. Victorian Government 3½% Inscribed Stock, 1921-1926, cost ...	300 0 0	
£296 4s. 9d. Dominion of Canada 3½% Inscribed Stock, 1909-1934, cost ...	300 0 0	
		600 0 0
,, *Cash*—Bank Deposit Account	212 3 10	
Do. Current Account	57 8 11	
In Secretary's hands—		
Entrance Fees of Candidates pending election	7 7 0	
Petty Cash	2 11 8	
		279 11 5
		£1,164 18 0

opinion the Balance Sheet is properly drawn up, so as to exhibit a true and correct view of the state of the affairs of the Institution as shown by the Books of the Institution.

(Signed) GEO. T. BULLOCK, *Acting Chairman, Finance Committee Meeting,* 9th October, 1907; LEWIS H. RUGG, *Chairman, presiding at Council Meeting,* 9th October, 1907.

WALTER T. DUNN, *Secretary and Treasurer.*

The Junior Institution of

Income and Expenditure Account for

EXPENDITURE.

	£	s.	d.	£	s.	d.
To *Expenses of Management*—						
Chartered Accountants' Fees	8	8	0			
Expenses of Ordinary Meetings	27	16	11			
General Printing and Stationery	49	1	1			
Office Expenses...	91	17	5			
Postages, Receipt Stamps, Telegrams, Parcels, &c.	36	19	5			
Salaries	310	0	0			
				524	2	10
,, *Expenses of Ordinary Excursions*	21	8	11			
Less: Receipts	17	17	0			
				3	11	11
,, *Conversazione, 13th March, 1907*	39	3	8			
Less: Receipts	37	8	0			
				1	15	8
,, *Summer Meeting, 29th June, 1907*	175	1	4			
Less: Receipts	169	8	3			
				5	13	1
,, *23rd Anniversary Dinner, 9th February, 1907*	55	14	10			
Less: Receipts	49	6	0			
				6	8	10
,, *Record of Transactions*—						
Vol. XVII.—Expended				300	18	2
,, *Library*	9	5	6			
Less Receipts	7	8	3			
				1	17	3
,, Institution Medal 26th Session				1	1	0
,, Delegate's Fee, Royal Sanitary Institute Congress ...				0	10	6
,, Income Tax				0	3	0
,, Furniture, Depreciation of				10	1	6
				856	3	9
,, Balance being Excess of Income over Expenditure ...				89	17	7
				£946	1	4

Engineers (Incorporated).

the year ended 30th September, 1907.

INCOME.

	£ s. d.	£ s. d.	£ s. d.
By *Subscriptions*—			
For the year 1906-7 ...	583 14 6		
In arrear at date—Estimated	130 0 0		
		713 14 6	
Deduct: Estimated arrears at 30th September, 1906	139 6 5		
Less: Amount received in respect thereof ...	89 9 6		
		49 16 11	
			663 17 7
,, *Record of Transactions*—			
Advertisements :—			
Vol. XVII.—Amount received	164 4 4		
Add: Amount due 30th September, 1907 ...	55 17 6		
		220 1 10	
Less: Vol. XVI.—Estimated due	46 0 0		
Less: Amount received ...	45 13 9		
		0 6 3	
		219 15 7	
Sale of Transactions		22 13 6	
			242 9 1
,, Interest on Investments			19 13 2
,, Interest on Deposit—Year to 30th June, 1907			3 0 9
,, Membership Badges			3 11 9
,, Sale of Works Management Lectures ...			6 10 0
,, Membership Certificates			6 16 4
,, Reading Cases			0 2 8
			£946 1 4

[See over for Benevolent Fund Accounts.

Benevolent Fund of the Junior Institution of Engineers.

INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 30TH SEPTEMBER, 1907.

Expenditure.	£	s.	d.	Income.	£	s.	d.
To Printing and Stationery	0	11	3	By Donations	81	13	0
,, Postages and Cheque Book	0	10	4	,, Subscriptions	26	3	3
, Balance being excess of Income over Expenditure transferred to Accumulated Fund	109	1	7	,, Interest on Investment	1	18	0
				,, ,, ,, Deposit	0	8	11
	£110	3	2		£110	3	2

ACCUMULATED FUND, 30TH SEPTEMBER, 1907.

	£	s.	d.		£	s.	d.
To Balance carried to General Balance Sheet	119	2	7	By Balance of Income and Expenditure Account at 30th September, 1906 ...	10	1	0
				,, Do. Do. at 30th September, 1907 ...	109	1	7
	£119	2	7		£119	2	7

GENERAL BALANCE SHEET, 30TH SEPTEMBER, 1907.

	£	s.	d.		£	s.	d.
To Balance at Credit of Accumulated Fund ...	119	2	7	By Barnet District Gas and Water Co. £100 Consolidated 4% Debenture Stock ...	100	0	0
				,, Cash at Bank	18	0	0
				,, Cash in hand	1	2	7
	£119	2	7		£119	2	7

We have examined the foregoing Accounts with the books and vouchers of the Fund and certify the same to be in accordance therewith. We have verified the Investment, and the cash at Bank.

(Signed) W. B. Keen and Co., *Chartered Accountants*,
Frank R. Durham,
Geo T. Bullock } *Honorary Auditors.*

Lewis H. Rugg, *Chairman of Committee of Management.*

Walter T. Dunn, *Hon. Secretary.*

7th October, 1907.

Part 2. **NOVEMBER, 1907.** **Vol. XVIII.**

The Junior Institution of Engineers

(Incorporated).

President - - WILLIAM B. BRYAN, M.Inst.C.E.

President-Elect - M. GUSTAVE CANET.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

7th November, 1907.

ANNOUNCEMENTS.

MONDAY, 18th November. **Meeting at 8 p.m. at the Institution of Civil Engineers,** Great George Street, by the kind permission of the Council. Presidential Address by **M. Canet** (Past President of the Institution of Civil Engineers of France), on "**The Latest Improvements in French and English Modern Artillery.**"

SATURDAY, 23rd November, at 10 a.m. Visit: The Royal Arsenal, Woolwich. Members intending to be present are requested to inform the Secretary **not later than 19th November,** when details of the arrangements will be issued to them.

TUESDAY, 10th DECEMBER. **Meeting at 8 p.m., at the Westminster Palace Hotel.** Paper on "**Arc Lighting,**" by MR. WILLIAM KRAUSE (*Member*), to be read and discussed.

SATURDAY, 14th DECEMBER, at 3 p.m. Visit: The Franco-British Exhibition Buildings, &c., in process of erection at Shepherd's Bush, for inspection of features of constructional engineering interest; **The Exhibition Extension Works of the Central London Railway**; and **The Central London Railway Power House.** Admission at the Wood Lane Second Entrance of the Exhibition on production of Badge of Membership.

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

COWEN, SAMUEL; Messrs. A. T. Banks and Co., 49 Mortimer Street, Cavendish Square, W.

FEILDEN, EDWARD SEARLE; Army and Navy Society, Engineer's Department, Victoria Street, Westminster.

HARRISON, CHARLES RICHARD; Messrs. Howarth, Erskine, Ltd., Singapore, Straits Settlements.

HINE, PHILIP THOMAS; Messrs. Bray, Markham and Reiss, Ltd., Walthamstow.

OVERING, EDWIN GEORGE; Messrs. Callender's Cable and Construction Co., Belvedere, Kent.

POOLE, HOWARD THOMAS; Coventry Ordnance Works, Coventry.

SWALES, ALFRED CLIFFORD; City Engineer's Office, Municipal Buildings, Leeds.

WALL, CHARLES; Messrs. Edward Deane and Beal, Ltd., 676 Old Kent Road, S.E.

Proposed for election to the class of "Associate."

MACDONALD, JOHN ROBERT, Jun.; Mr. H. Howard Humphreys, 28 Victoria Street, Westminster.

PERSONAL NOTES.

CHARLES BENTALL has joined the Canadian General Electric Co., of Peterborough, Ontario; 283 Park Street, Peterborough, Ontario.

ARTHUR BINGHAM has obtained an appointment in the Drawing Office of the British United Shoe Machine Co., Union Works, Leicester.

CHAS. H. BOWEN, appointed Assistant Engineer on the Southern Mahrattan Railway, Dharwhar, India, sailed on the 1st November, by the P. and O. SS. "Marmora," to Bombay.

VINCENT H. CHABOT, from Trichinopoly, Madras, expects to be in London this month; he has arranged to motor from Marseilles.

A. KNIGHT CROAD has recently been elected a Member of the Institution of Engineers and Shipbuilders in Scotland.

GEO. E. CLARE, who was appointed Engineer Instructor at the Technical College at Osaka, Japan, writes from there that the College is a very large one, comprising various departments. The Engineering side includes drawing office, fitting and machine shops, smiths, patternmakers, and boiler shops, also a foundry. At present a number of machine tools are being made, and a Lancashire boiler is in process of construction. Upwards of seventy workmen are employed, so that the students now going through their course, have an exceptional opportunity of getting a good insight into practical work.

EDWARD GOFFE is returning to South Africa about the middle of November, after having spent some months leave at home. One of the first duties in Johannesburg claiming his attention will be the examination for the Diploma in Mining, conducted by the University of the Cape of Good Hope, he being one of the Examiners in Mechanical Engineering.

W. H. GORTON has received an appointment in the Railway Branch of the Public Works Department of India. Home address, Little Hill, Instow, Devon.

ADAM HUNTER has recently been elected a Member of The Institution of Engineers and Shipbuilders in Scotland.

H. H. KLITZ is on a voyage to Japan and Australia as third Engineer on the P. and O. SS. "Palermo."

W. G. MAGDELIN has been appointed Assistant Works Manager to Messrs. R. Waygood and Co., Ltd., Vulcan Iron Works, Coventry.

HUBERT W. PHILPS has entered the Drawing Office of the City Gas Works, Saltley, Birmingham.

ALFRED SAUNDERS is now with the London and South Western Railway Company, at their Bournemouth Depôt; address, "Newtonhill," Orcheston Road, Malmesbury Park, Bournemouth.

F. P. TALBOYS sails on the 13th November, by SS. "Majestic," for New York *en route* to Dunedin, N.Z., *via* Canada, Vancouver, Sydney, Melbourne, Auckland and Wellington. Address, 2 Brown Street, Dunedin.

W. V. TREEBY is going to West Hartlepool, having been appointed to take charge of the "contra flo" condenser drawing office of Messrs. Richardson, Westgarth and Co.

SYDNEY J. WATERS has become Head Draughtsman in the Petrol Engine Department of Messrs. J. Taylor and Sons, York Road, Islington, N.

HAROLD E. YARROW has recently been elected a Member of the Institution of Engineers and Shipbuilders in Scotland.

Appointments.

106. Wanted—An Engineer, thoroughly experienced in the manufacture of incandescent electric lamps, for a works at Osaka, Japan. Salary £35 per month.

107. A Draughtsman, age about 30, is wanted for a marine engineering works in South America. Good salary to a suitable man.

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208. Member, age 21, desires engagement in a Mechanical Engineer's Drawing Office; four and half years' shop and drawing office experience; good theoretical training.

209. Member, age 26, seeks position in London or district. First Class Board of Trade Marine Engineer's Certificate; shops, drawing office and sea experience; fluent knowledge of French.

210. Member, age 32, is open to engagement in Mechanical Engineer's Office. London or provinces.

FROM THE STARTING PLATFORM.

THE PATENT AND DESIGNS AMENDMENT ACT, 1907.

A patent, although always a monopoly, possesses a different aspect in the two instances of a wealthy manufacturer, and a clever workman of limited means. Generally the latter, in the case of joint applicants, is the "first and true inventor" within the strict meaning of the phrase, but owing to his lack of ability to properly protect his invention, and afterwards place it on the market, he is forced to seek assistance. This culminates in a joint application, in the usual way of procedure.

In Section 37 of the New Act we learn that "subject to any contract to the contrary, each of such persons shall be entitled to use the invention for his own profit without accounting to the others, but shall not be entitled to grant a licence without their consent," &c. In the case referred to, the partner who is able to effect this one-sided profit-making, is the party possessing most money; in the majority of cases he is the employer of the real inventor and co-patentee who, for lack of means, will perhaps have to put up with any scraps that may be thrown him.

True, a covenant may be made anterior to the application, whereby the profit-sharing is defined and agreed, but as such an

instrument must refer to, and be based upon, a patent, and this is not granted at the time of execution, the deed is perforce null and void. Therefore, unless the document expresses an agreement in respect of the "invention," by the New Act the poor inventor may be squeezed out by the wealthy "joint applicant."

The object sought to be attained was that an obstinate or recalcitrant co-patentee should not block the commercial progress of a patent. But like many laws affecting individual rights, the one in question is decidedly adverse to the interest of the person having the least money.

No doubt the intention of the draftsman of Section 2, subsection 5, was to prevent the frivolous patenting of hastily worked out processes. Now, in many instances, such as dyes, solutions for tempering steel, &c., a sample would be of no assistance to the Examiners, nor even to an analytical expert, failing the peculiar conditions incidental to the practical application of the chemical compound. And in many cases the production of the smallest quantity of a compound might necessitate expensive apparatus, which of course would not be established unless a patent was obtained.

To sum up, the new sub-section enables the Examiner, through the Comptroller, to give an applicant for a chemical patent a great deal of needless trouble, which at the same time affords no evidence of novelty or utility. A good description, aided by symbolic formulæ should suffice for all purposes. If an application is frivolous, impossible in practice, or should have been anticipated, these points are determinable by such description and formulæ without the analysis of a sample. Again the condition imposed is one which gives an advantage to a wealthy manufacturer over inventors having small means. Also there is the germ of compulsory manufacture, a state of affairs to be deplored wherever enforced.

There is a brighter outlook for the inventor in respect of the grant of Patents of Addition (Section 19) since it frequently happens that continued practice evolves improvements on the original invention, and it is only fair that there should be an opportunity provided whereby such improvements may be tacked on so as to form an integral part of the patent proper, as a property, both to an assignor and assignee, where "subsequent improvements" are included in an agreement. And that there

should be no additional renewal fees is an adequate provision, making these Patents of Addition dependent upon the mother patent; in other words, the whole is, as a property consolidated.

Section 15 provides for the revocation of a patent which has been worked abroad but not "adequately" in the United Kingdom. The object of this is laudable, inasmuch as the desire to promote home manufactures is beneficial to the community, and savours of patriotism. But it is a drastic remedy, and one which the writer considers should not lightly rest upon the shoulders of officialdom. As it stands, to become law in 1908, the decision lies first with the Comptroller, then considered by the Board of Trade, the final and absolute decision being that of the Court.

Supposing a patentee in the United Kingdom possesses, under the Convention, certain Foreign patents, and that these are being successfully worked in the several countries. The English are proverbially averse to dealing with "new fangled" ideas, and only grow acccustomed to them by such foreign usage proving utility, and rendering the invention of common knowledge. This process of induction is, with the hard-headed Briton, very slow, but meanwhile the patentee is liable to the revocation of his patent. And that is not all; the Foreign patents under the Convention expiring with the British patent, are lost also. This is manifestly an injustice, notwithstanding the admission of evidence in the way of "satisfactory reasons," which is too shadowy and vague to constitute a definite status. In fact, the mere wording of the Act lends itself to a bias adverse to the patentee. And, considering also the expense of the proceedings, even before the Comptroller, where counsel must be retained, and evidence procured and paid for, the section is a fine and delicate tool for enforcing working of patents; rendering it *de facto* compulsory, which is an infringement of the liberty so dear to the Britisher.

The section is too stringent and severe to meet *any* case, and is notoriously objectionable in the instance quoted above. Some people doubt the technical knowledge of a Judge in patent cases, arguing the expensive process of instructing him through counsel. If a special technical Judge were appointed to try such cases, he would still be fallible, and not equally well informed in each branch of applied science. And the legal process would

still be expensive. In the writer's opinion such a serious decision as that affecting the revocation of a patent should lie with no individual, but if necessary at all, should be referable to, and dependent upon, the Privy Council, and should be open to representation to that body through the patentee and his Patent Agent; and the requirement of the attendance of specially appointed solicitors and King's Counsel should be abolished.

The Section 84-85 referring to Patent Agents, is still not protective to them as a body, nor to their clients; the loose wording allowing the widely advertised patent "expert" to delude the unwary, and carry on business as of yore. Considering the annual fee paid by legitimate patent agents, they are not adequately protected, nor is the would-be patentee any more secure for the protective section than he was before. It is not necessary for an "expert" to officially bring his name before the Comptroller, thus courting detection and refusal, the *modus operandi* being for the client to sign his papers as from the expert's address.

In conclusion, there really does not appear to be much in this fresh Act. It is to be feared that what is new is too crude to stand the test of working, so yet another Patent Amendment Act may be imminent.

BENJ. T. KING.

OBSERVATIONS IN GENERAL.

The announcement of the delivery on Monday, 18th November, by our President-elect (M. Canet) of his Inaugural Address on "The Latest Improvements in French and English Modern Artillery" is arousing considerable interest, not only in the Institution itself, but in naval and military circles, and amongst ordnance engineers generally.

* * * * * *

This circumstance, together with the keen desire which we know exists to accord M. Canet the warmest possible welcome on his appearance amongst us, justifies the belief that we shall have an unusually large attendance at the Institution of Civil Engineers in Great George Street on the occasion in question.

Although the seating capacity of the historic meeting hall, so kindly placed at our disposal by our elder brethren, is larger than that to which we are accustomed elsewhere, members will be well advised to come with their visiting friends in good time, if they wish to avoid the possibility of "standing room only." The proceedings commence at eight o'clock.

* * * * * *

An observation on the Scrutineers' report at the Annual General Meeting, which appears in our present issue, is called for from the fact that it contains the name of the fourth brother of the house of Henry Young, who has been elected to serve the Institution in an official capacity.

* * * * * *

The pleasure of seeing Dr. Lilly at our meeting the other evening contributing to our Transactions on "The Economic Design of Hollow Shafts," revived recollections of his occupancy of the author's chair on a former occasion, to trace the date of which one has to go back to November, 1889, when he dealt with the equally interesting though perhaps less abstruse subject of "The Modern Marine Boiler."

* * * * * *

"The Model Engineer" Exhibition, which the Institution was recently privileged to visit, must have convinced many people that "model engineering" had become fully recognised as a department of serious technical effort, possessing many valuable applications.

* * * * * *

A Lecture, with demonstrations, on "The Gyroscope," given at the Exhibition by Mr. W. J. Tennant, with his characteristic lucidity, attracted a large audience, in which were included Professor A. G. Greenhill, F.R.S., and Mr. Louis Brennan, the inventor of the Brennan torpedo, and who, it will be remembered, was recently engaged in perfecting his monorail railway, in which the controlling action of two pairs of gyrostats rotating in opposite directions, maintains the equilibrium of his vehicle.

* * * * * *

The Manchester Gas Exhibition, under the auspices of the Manchester District Institution of Gas Engineers, and the Society

of British Gas Industries, over which latter body Mr. Dugald Clerk, our Past-President, presides, is now in full swing at the St. James' Hall, and is already pronounced a great success.

* * * * * *

A number of technical lectures have been arranged for delivery during the progress of the Exhibition, which closes on the 9th of November, amongst them being one by Mr. Clerk on "Coal Gas for Power and Heating."

ANNUAL GENERAL MEETING.

The Twenty-sixth Sessional General Meeting (and Third Annual General Meeting of the Incorporated Institution), was held at the Westminster Palace Hotel, London, on Friday, 18th October, 1907, the chair being taken at 7 p.m. by Mr. Lewis H. Rugg, Chairman. Attendance 88.

The Minutes of the Annual General Meeting of 16th October, 1906, and of the Ordinary Meeting of 8th May, 1907, were read, confirmed, and signed by the Chairman.

Mr. R. F. Krall and Mr. P. W. Palmer were appointed Scrutineers of the ballot lists for the election of Officers and Members of Council for service during the Twenty-seventh Session, 1907-8. The ballot was declared open, duly continued open for the period of one hour, and was then closed.

Mr. W. A. Tookey moved, Mr. R. Marshall seconded, and it was resolved, "That the Annual Report of the Council for the year 1906-7, having been issued to the members in the current number of *The Journal*, be, and is hereby taken, as read." (See page 25 *ante*.)

The Chartered Accountants' Report relating to the same period was submitted—a copy of the Balance Sheet and Accounts as at 30th September, 1907, duly certified, having been previously issued to the members.

Mr. H. Norman Gray (Joint Hon. Auditor with Mr. L. F. Ferreira, who was unavoidably absent) presented the Hon. Auditors' Report.

Moved from the Chair, seconded by Mr. F. R. Durham (Vice-Chairman), it was resolved unanimously "That the Report and Accounts be, and are hereby, accepted and adopted."

Mr. G. T. Bullock proposed, Mr. C. H. Smith seconded, and it was resolved "That Messrs. W. B. Keen and Co., Chartered Accountants, be, and are hereby, appointed Professional Auditors for the annual audit of the books of the Institution for the year ending 30th September, 1908."

On the motion of Mr. W. H. Shephard, seconded by Mr. H. P. Philpot, it was agreed by acclamation "That the best thanks of the Members be accorded the Officers and Members of the Council for the excellent services which they have rendered the Institution during the past year."

The Chairman having acknowledged the vote of thanks, suggestions whereby the usefulness of the Institution might be further improved were invited, and in that connection the following letter from the President-elect was read:—

LA TOURELLE,
ST. AUBIN-SUR-MER.

WALTER T. DUNN, ESQ. *13th July, 1907.*

DEAR MR. DUNN,

The Junior Institution of Engineers having done me the honour of electing me their President for the coming year, I feel that I should like to express in some practical manner my interest in the Institution and my sympathy with its objects.

I understand that it is the aspiration of the members, that the Institution shall possess at some future date a permanent home of its own, where its work may be carried on and the members may meet under greater advantages than are at present possible.

The rapid growth of the Society points to the eventual necessity of such a home, and I feel I cannot do better to show my appreciation of the past work of the Junior Engineers and my confidence in their future than by furthering this object.

I therefore have pleasure in asking the Council to accept the sum of £100 (one hundred pounds) for the purpose of inaugurating a building fund. I shall feel it a privilege to have had the opportunity of making the first contribution to a fund, which once started, will, I trust, speedily grow and result in the provision of a building worthy of the Junior Institution.

Yours faithfully,
(Signed) G. CANET.

Before proceeding with the ordinary business of the evening the Chairman referred in feeling terms to the recent death of

Mr. Basil P. Ellis, Honorary Member, and proposed that a letter be sent conveying to Mrs. Ellis and her family the respectful expression of the Institution's sympathy. The members signified their assent by silently rising from their seats.

A Paper on "The Economic Design of Hollow Shafts" was read by Professor W. E. Lilly, D.Sc., of the Engineering Department, Trinity College, Dublin (Member of Council representing Irish Districts).

The discussion upon it was opened by Mr. H. P. Philpot, who also proposed a vote of thanks to the Author for his paper, which, seconded by Mr. Edward Goffe, was carried by acclamation. Mr. M. T. Ormsby, Mr. W. H. Shephard, Mr. John Clegg and Mr. George Gentry were the other speakers in the discussion.

The Scrutineers reported the election to have resulted as follows:—

Chairman: Frank R. Durham.

Vice-Chairmen: Fred. S. Pilling and George T. Bullock.

Hon. Librarian: Chas. H. Smith.

Hon. Auditors: H. Norman Gray and G. C. Allingham.

Members of Council: F. D. G. Napier, R. H. Parsons, Chas. W. Pettit, and Douglas S. Young.

Provincial Members of Council:—

North of England: Chas. T. Briggs (Newcastle-on-Tyne).

West of England: John W. Kitchin (Bristol).

Midlands: Ernest King (Sheffield).

Scottish Districts: Harold E. Yarrow (Glasgow).

Eastern Counties: George H. Hughes (Walton-on-the-Naze).

Irish Districts: Walter E. Lilly (Dublin).

Southern Counties: Chas. P. Raitt (Portsmouth).

Welsh Districts: Herbert F. Hunt (Pembroke).

Mr. Durham having been duly inducted to the Chair, expressed his appreciation of the honour which had been conferred upon him. He then moved a vote of thanks to the Scrutineers for having discharged their duties. Seconded by Mr. Rugg, the motion was carried, and the ballot lists were destroyed.

The Author's reply to the discussion followed; and after a vote of thanks had been passed by acclamation to the retiring Chairman, on the proposal of the Chairman, seconded by Mr. W. J. Tennant, the proceedings terminated with the following announcements:—Friday, 25th October, visit to the "Model Engineer" Exhibition; Saturday, 26th October, inspection of the Blackfriars Bridge Widening Works; Monday, 18th November, meeting for the delivery of M. Canet's Inaugural Address on "The Latest Improvements in French and English Modern Artillery."

BENEVOLENT FUND.

SECOND ANNUAL GENERAL MEETING.

The Second Annual General Meeting of the Contributors to the Benevolent Fund was held at the Westminster Palace Hotel, London, on Friday evening, 18th October, 1907, Mr. Lewis H. Rugg, Chairman of the Committee of Management, presiding.

The Minutes of the last Annual General Meeting of 16th October, 1906, were read, confirmed, and signed.

Moved from the Chair, seconded by Mr. John E. Raworth, and supported by Mr. F. R. Durham, it was resolved that the Annual Report of the Committee having been issued to the contributors, be taken as read; and that it be accepted and adopted.

On the proposal of Mr. Henry Cook, seconded by Mr. J. Wylie Nisbet, a vote of thanks was passed to the Officers and Committee for their services to the Fund during the past year, and Mr. Rugg acknowledged it.

The Scrutineers—Mr. R. F. Krall and Mr. P. W. Palmer, subsequently reported that the election had resulted as follows:—

Committee of Management:

The President of the Institution.
The Chairman of the Institution.
Wm. John Tennant, J. Wylie Nisbet } representing the Council of the Institution.
Geo. T. Bullock.
B. E. Dunbar Kilburn.

Hon Auditors: Ebenezer Eade and D. N. Hunt.

VISIT: "THE MODEL ENGINEER" EXHIBITION.

The First Visit of the Twenty-seventh Session took place on Friday evening, 25th October, 1907, to "The Model Engineer" Exhibition at the Royal Horticultural Hall, Vincent Square, Westminster, by the kind invitation of the Organisers, Messrs. Percival Marshall and Co.

Mr. Percival Marshall (Past-Chairman) received the members as they arrived at 7 p.m., the attendance being 69. At the conclusion, Mr. Frank R. Durham, Chairman of the Institution, conveyed to him the expression of their appreciation of the facilities so courteously extended in connection with the occasion.

The following has been taken from the introduction to the Exhibition Catalogue, and reference may also be made here to the paper on "The Uses of Engineering Models," which was read by Mr. Percival Marshall before the Institution in 1902. (See Transactions, Vol. XII., page 106, fully illustrated.)

This Exhibition, the first of its kind ever held, has been organised by the proprietors of "The Model Engineer" to publicly demonstrate the position of model engineering as a hobby, as an aid to technical education, and as a business. In the minds of many people the mention of the words "model engineering" conjures up visions of tin boilers, soft solder, and methylated spirits, and the whole thing is scoffed at as an ordinary boyish amusement. A glance round the various exhibits will dispel this notion completely, for one cannot see the beautiful examples of high mechanical skill, the wonderful ingenuity, and the great variety of design here displayed without being compelled to admit that model engineering is a pursuit which makes demands of no small order upon its followers.

As a hobby, the pastime of model-making is followed both by juveniles and adults, by rich and by poor, and by members of every calling and profession. To the boy it affords a means of giving vent to his mechanical ideas and ambitions, and it can safely be said that the young model-maker of to-day may well become the George Stephenson, the Brunel, or the Lord Kelvin of to-morrow. Indeed, the life story of almost every famous engineer has the influence of early model-making efforts writ large upon it. To the adult, the charms of model engineering as a recreation from the cares and worries of business or professional

work are many. It possesses in a marked degree the two great characteristics of real recreation—a complete change of occupation and the necessity for complete concentration of the mind on its execution. It is practised by doctors, musicians, lawyers, clergymen, actors, artists, naval and military officers, stockbrokers, bankers, commercial men, shopkeepers, and so through every walk of life down to the village postman or shoemaker, and each according to his lights finds enjoyment and physical and mental benefit in its many and varied possibilities. One of the most remarkable things in connection with model engineering is the high degree of mechanical ability possessed by many amateur engineers, and there are numerous examples of amateur work in this Exhibition which will compare with the finest products of professional training and experience. Perhaps not the least important point in favour of model engineering as a hobby is its adaptability to all purses and to all capacities. The equipment may range from a few tools and inexpensive materials to an elaborate workshop fitted with every appliance and convenience which money can procure, while the designs attempted may vary from the simplest form of windmill, water-wheel, or pump, to a scale model of an express locomotive or a triple expansion marine engine or steam turbine of the latest type, while in the fascinating domain of electricity and of optical and scientific apparatus there is scope for all the skill and ingenuity it is given to mortal man to possess. It is, in fact, a hobby which is within the power of everyone to follow, but of no one to exhaust.

As an aid to technical education, model engineering has much in its favour. The knowledge which is gained in the actual construction of a model steam engine, of a small gas or oil engine, of a dynamo or an electric motor, is worth more than that gained from many books or many lectures. The details of construction, the principles of working, the relationship and the relative importance of the various parts of a piece of mechanism, are grasped far more readily by the actual making than by the reading or hearing of an explanation, and the truth of this statement is amply borne out by the excellent knowledge of engineering construction and principles possessed by many amateur engineers who have never attended a technical class in their lives.

As a business, model engineering is now of greater importance than it has ever been before. From the point of view of business

service, the use of models is developing rapidly, and for the easy and convenient demonstration of inventions and of the working of various classes of machinery, a large number of models are in daily use. Similarly, for the purposes of technical instruction, working models are rapidly growing in favour, and this all creates business for the growing number of firms who devote themselves to this class of work. The increase in the number of models made, both commercially and privately, naturally brings an increased demand for castings, fittings, materials, and tools, and quite a number of substantial and responsible firms are now catering especially for these requirements. To give some slight idea of the amount of trade done it is computed on quite a modest basis that the readers of "The Model Engineer" alone spend well over £100,000 per annum on their model work.

"DEEP SEA DIVING AND CAISSON WORK."

Lecture by Dr. LEONARD HILL, M.B., F.R.S.

Delivered 26th September, 1907, on the occasion of the visit of the Institution to the Engineering and Machinery Exhibition at Olympia.

COL. SIR EDWARD RABAN, K.C.B., R.E., PAST-PRESIDENT, IN THE CHAIR.

Compressed air is used in all the great subaqueous works of to-day, in tunnelling, pier sinking, bridge building, diving, &c. All such works are limited to a certain depth by the pathological effects produced on the workers.

The naked diver preceded the diver who uses compressed air. The body of the naked diver is pressed upon by the water, equally and in all its parts, by a pressure equal to + 1 atm. (15 lb. per square inch) for every 33½ feet (10·3 m.) of depth. He fills his lungs before, and holds his breath during, the dive. The air in his lungs must be compressed to half its volume at 33½ feet (2 atm. abs.), to one-third at 67 feet (3 atm. abs.), to a quarter at 100½ feet (4 atm. abs.), and so on. The depths attained are usually not greater than 60 to 70 feet.

The duration of his stay under water is limited by the oxygen-carrying power of his blood. This may become greater by practice. Diving birds have double the normal volume of blood (Bohr). The diver who uses gear, or the caisson worker, is surrounded with compressed air and breathes freely in it. The body of either is pressed upon by the air, and the air pressure must always be just greater than that of the water to keep the latter out of the helmet, bell, or caisson. Whether it be air or water that *uniformly* presses upon the body the tissue fluids transmit the pressure equally throughout the body, and thus although it is computed that + 1 atm. means an additional total pressure of 15,000 to 20,000 kilograms (40,000 lb.) on the body of a man, no mechanical effect is produced. Living matter is a colloidal solution, containing about 80 per cent. of water, and is practically incompressible.

The theory, put forward by many medical writers, that congestion of the blood in the deeper parts of the body can be

induced by variations of atmospheric pressure, is contrary to physical principles, and is quite untenable.

I can refute it by the following experiment: A frog's web is stretched over the glass window of a pressure chamber, and is illuminated by the arc light, so that the circulation of the blood is projected on the screen. The circulation remains unchanged when the pressure is raised to 20 atm. Manometric records of blood pressure in mammals also show no noteworthy change.

That mere mechanical pressure uniformly applied is of little importance to living matter is shown by the existence of life in the greatest depths yet sounded, where the superincumbent pressure may equal 2 to 3 and even 5 miles of water. Regnard, using a hydraulic pump and steel chamber fitted with glass windows, has compressed living aquatic animals up to 500 and even 1,000 atmospheres.

The use of compressed air for submarine work was a matter of slow development, owing, not to lack of invention, but to want of efficient air pumps and flexible tubes. The oldest invention is that of a pipe conveying air from the surface to the mouth of the diver. Such a device cannot be used at any depth, because the body is pressed upon by the water plus the atmospheric pressure, while the lungs are exposed to the atmospheric pressure alone (model demonstrated). The pressure of the water on the body makes breathing difficult and congests the blood within the lungs. The cupping glass demonstrates the congestive effect produced by lessening the atmospheric pressure at one part of the body only.

The same bad conditions pertain to the water-tight metal helmet, combined with leather dress, suggested by Borellus (seventeenth century), the diver being supposed to live on the air in the helmet.

Bernouilli formulated the correct theory that the diver must either be supplied with air at the pressure of the water surrounding him, or that Borellus' helmet must be made of leather so that the air within can be compressed by the water. The Venetians (seventeenth century) pumped air into a diver's helmet with a bellows, and thus forestalled by two centuries the modern diving dress of Siebe, Gorman and Co. (model demonstrated).

In the older inventions the air escaped from under the helmet and only the head was dry. The air pressure now keeps the

water from entering the dress at the wrist cuff, and the whole body is kept dry and warm.

Any one who pushed an inverted glass under water and saw it did not fill, would conceive the idea of a diving-bell. Sinclair (1665) fashioned a simple wooden bell to recover treasure from an Armada ship off Mull. At 33½ feet the air in such a bell is compressed to half its volume, and this, together with lack of ventilation, rendered such a bell of little use.

Halley, the astronomer, used a pipe and bellows for shallow work, while for deep work, when his bellows failed, he sank a cask full of air to a deeper level than the bell. From the cask to the bell passed a tube, and the water entering the cask through a hole displaced the air into the bell (model demonstrated). He descended to 9 to 10 fathoms with four others, and used up 7 to 8 barrels of air.

With the building of efficient air-pumps, Smeaton (1778) applied the bell to the important use of building the piles of bridges. Triger (1839) applied it to the sinking of excavation through quicksands, and the bell became evolved into the modern caisson—a steel chamber provided with a cutting edge below, and an air-lock above for allowing the men to enter and leave without raising the bell. Finally the caisson was applied to the purpose of horizontally tunnelling under rivers. To effect this a steel shield provided with cutting edge, is driven forward by hydraulic jacks. Screens are placed in the shield to allow excavation of the soil in front of it. As fast as the shield is driven forward, segments of the iron tunnel are built into place. Water is kept out of the work by the use of compressed air. On entering, the men are "compressed" in the air-lock, *i.e.* the air-pressure is raised to that in the tunnel, and on leaving the tunnel they are "decompressed," *i.e.* the air-pressure is lowered in the lock down to the normal, so that the outer door of the lock may be opened.

A diver is "compressed" on descending into the water, as the pressure of his air-pump always keeps up to that of the water. On coming up he is "decompressed."

The workers in compressed air from first to last have suffered from illness and loss of life. The higher the pressure, the greater the loss. Thus there occurred at:—

Douchy mines (shaft sinking)...	63 cases (Pol and Watelle).
Kehler bridge (Rhine) ...	133 cases (François).
Adour bridge	90 per cent. of workers (Limousin).
St. Louis bridge (Mississippi)	119 cases out of 352 workers; 50 cases of paralysis; 14 deaths) (Eads, Jaminet).
Brooklyn bridge	110 cases in 4 months and 3 deaths (Smith).
Toulon dry dock	43 cases in 3 weeks and 2 deaths.
Cubsac bridge	104 cases and 3 deaths (Gerard).
Eider bridge	38 cases and 2 deaths (v. Haller).
Nussdorf works (Danube) ...	320 cases among 675 workers (v. Schrötter).
Felesti bridge (Danube) ...	55 cases and 5 deaths among 154 workers (Tinc).
Hudson tunnel...	1 man died a month among 50 workers, until the conditions were altered (E. W. Moir).

Many cases of illness and death occur also among deep-sea divers. Catsaras (1890) published accounts of 70 cases collected from the Greek sponge divers. He averaged the deaths as 10 per annum in the sponge fisheries of Hydra. Compressed air sickness is characterised by its protean symptoms. Catsaras records cases of loss of speech, blindness, deafness, transitory madness, vertigo, loss of consciousness, subcutaneous emphysema, spinal paralysis, &c. V. Schrötter, at Nussdorf, observed 68 cases of ear trouble, 105 of pain in the muscles, 60 of pain in the joints, 10 of girdle pains, 17 of partial paralysis, 26 of paralysis of the lower half of the body, 14 of vertigo and noises in the ears, 2 of sudden deafness, 1 of loss of speech, 13 of asphyxial phenomena.

None of the symptoms, with the exception of some slight ear trouble, ever occur while the men are under pressure. Mules were kept a year in the Hudson tunnel, and were healthy enough to kick and bite at all comers (Moir). The illness comes on after decompression, usually within a few minutes to half an hour, sometimes even later. The trouble in the ear, which occurs during compression, is due to the inequality of air-pressure on either side of the drum of the ear. It is relieved at once by opening the Eustachian tubes by swallowing, or, if this is not enough, by a forced expiratory effort with the nose and mouth shut.

Many and conflicting were the theories of compressed air illness, and in the directions given to avoid it. Some medical men (Pol and Watelle) recommended slow, and others, like Foley,

rapid decompression. All was made clear by a remarkable series of experiments carried out by Paul Bert on animals between 1870 to 1880. By these experiments he not only proved the cause, but found the means of prevention.

Bert showed that nitrogen gas is dissolved by the blood and body fluids in proportion to the pressure of the air, and that the gas bubbles off in the blood, when an animal or man is rapidly decompressed. The bubbles may block up the capillaries in one or other part of the body, and by cutting off the part from blood supply, produce one or other of the symptoms mentioned above. The illness is prevented by making the period of "decompression" sufficiently slow, *i.e.* by allowing time for the dissolved nitrogen to escape from the lungs.*

Bert's experimental results have been confirmed and extended particularly by H. V. Schrötter and myself, and my colleagues, J. J. R. Macleod, C. Ham and M. Greenwood. The whole matter in consequence is placed on a sure footing.

Exposed to 1 atm. at body temperature, blood dissolves just about 1 per cent. N_2, to 2 atm. 2 per cent., to 3 atm. 3 per cent., and so on. The tissue fluids take up the dissolved gas from the blood, and with time the whole body becomes saturated, according to Dalton's law. The saturation of the body fluids takes time, since the blood forms but 5 per cent. of the whole body weight, and it is the blood alone that comes in direct contact in the lungs with the increased atmospheric pressure. Probably about 5 kilograms of blood circulate through the lungs per minute, and this blood conveys the absorbed nitrogen to the 70 kilograms of tissues which is the average weight of the body. The arterial blood saturated in the lungs yields the nitrogen to the tissues, and returns to be saturated again in the lungs. Those tissues, which are plentifully supplied with blood, will become saturated rapidly, while less vascular areas, and parts in a state of vaso-constriction, will saturate very slowly.

C. Ham and I exposed rats to 10 to 20 atm., killed them by instant decompression, and then opening their bodies under water, collected and analysed the gas set free therein. We obtained in this gas CO_2 6·7—16 per cent., O_2 2·1—8·7 per

*Boyle, 200 years previously, had shown that gas bubbles appeared in the humours of the eye of a viper, when submitted to a rapid evacuation under the air pump.

cent., N_2 80—87 per cent., and a volume of N_2 even greater than that calculated by Dalton's law. Some of the excess we found was due to gas swallowed while under pressure. Vernon recently has found that oil or fat shaken with air dissolves five times as much nitrogen as water does. It has not yet been determined whether this remarkable fact holds good for the body. Oxygen as well as nitrogen is dissolved by the water and fat of the body, but this is of no importance, because the oxygen chemically combines with the blood and tissues on decompression. Most of the gas, set free on decompression from high pressures, is free in the peritoneal cavity and alimentary canal.

M. Greenwood and I have tested upon ourselves the rate of saturation, using the urine as a test fluid. We were compressed in a large boiler, placed at our disposal by Messrs. Siebe, Gorman and Co. The chamber was fitted with electric light and telephone, and taps for slow decompression. The pressure was raised by means of a diving pump driven by a gas engine. We drank a quart of water before entering, and collected samples of urine at varying pressures and times. The urine, collected in sealed bulbs, was evacuated by my blood gas pump (demonstrated). We found the urine secreted in the next ten minutes after reaching any given pressure is saturated with N_2 at that pressure.

To demonstrate the bubbling off of nitrogen on rapid decompression, I have spread the web of frog's foot or wing of bat over the glass window of a pressure chamber. The circulation of the blood is projected on a screen with aid of microscope and arc light. We can thus observe the circulation under 20 atm. of air, and watch the bubbles forming in the capillaries on rapid decompression. Recompression diminishes the size and finally drives the bubbles again into solution.

When the larger mammals are exposed to high pressures, such as 8 atm., for an hour or so, and are then rapidly decompressed, they usually die in a few minutes. Small mammals, such as mice and rats may escape, owing to the small bulk of body, and great rapidity of circulation, this being sufficiently rapid to clear out the nitrogen. The young of rabbits, cats, &c., also escape more frequently than old animals. This probably is due rather to their smaller weight and more rapid circulation than to the youth of the body tissues. After the decompression,

the animals show signs of sensations in the limbs, which they lick or bite at, paralysis in the limbs follows, and then the animals fall over and become unconscious. Noise of gas bubbles gurgling in the heart may be heard. Respiration becomes embarrassed, and the animals die. On dissection, the peritoneal cavity may be found distended with gas, or the stomach, and bubbles of gas may be seen in the intestine. A part of this gas arises from the fermentative processes of digestion, and from air swallowed during compression. The veins of the portal system, the venæ cavæ, &c., are seen to contain chains of bubbles; the heart is full of froth. Small hæmorrhages may be present in the lungs. The edges of the lobes of the lung are emphysematous, blown out by the rapid decompression. The fat often is full of small bubbles, so too are the connective tissues. Bubbles are seen in the joints, and may appear in the aqueous humour of the eye. On opening the skull, bubbles are seen in the veins of the brain. The bubbles are not restricted to the veins, but may also be seen in the arteries. The coronary vessels of the heart often show chains of bubbles. On microscopic examination, the bubbles are seen in the capillaries; here and there they run together and form larger bubbles, sometimes rupturing the walls of the vessel, and compressing the surrounding tissues. The bubbles appear in the lymph spaces and lymphatics equally with the blood system. In the larger animals decompressed from 100 lbs. in 4 to 7 seconds, we have found the cells of the liver, kidney, &c., vacuolated or even burst by bubbles. The gas set free in the heart can be collected and analysed; about 80 per cent. of it is found to be nitrogen (Bert, v. Schrötter, Hill and Macleod). Catsaras lowered dogs in a diving dress to depths of 43·7 m., and after about an hour rapidly drew them to the surface. He found bubbles set free in these dogs just as in those exposed in a pressure chamber.

In animals which escape without any severe symptoms, gas bubbles may be found in the veins six hours later. This shows how long it may take for nitrogen gas once set free as bubbles to escape from the lungs, and explains why caisson workers may suddenly be seized some half-hour or more after leaving the works. In such cases the bubbles may be swept from the abdominal veins—where they do no harm—into the heart, and impede the action of this organ, or they may penetrate the pul-

monary circulation, and enter the arterial system, and block up, perchance, the coronary arteries, or others in the brain or spinal cord. The blood is a colloidal solution, and it takes time for the nitrogen to come out of solution and for the small bubbles to run together to form visible bubbles. We find colloidal solutions form super-saturated solutions after exposure to high pressures. After decompression the gas does not come off until the solutions are shaken several times while water is cleared of gas by one shake. I surmise that the gas molecules are tacked on to the colloidal particles, and that skins of proteid antagonise the union of the gas molecules with each other.

The gas bubbles tend to collect in the veins, as the blood travels quickly through the arteries and slowly in the veins. It is only when the gas in the veins becomes sufficient in amount to produce foam in the heart, or when gas bubbles block up arteries of vital import, that grave symptoms arise. The place where bubbles in the arteries must always produce serious results is the central nervous system. In the liver, kidneys, muscles, fat, &c., bubbles may embolise small arteries and produce no grave effect, but in the spinal cord the interruption of the blood supply to any group of cells or tract of fibres, is evidenced at once by pain and anæsthesia, spasm and paralysis. In the medulla oblongata arrest of the circulation will stop respiration, and bubbles lodging there may produce immediate death. Lodging in the arteries of the great brain, bubbles may produce hemiplegia, aphasia, blindness, or mental disturbance.

Among men some are affected and others not. We can look for an explanation in the varying state of that colloidal solution, the blood, in the varying vigour of the circulation and respiration and the effect of fatigue, in vaso-motor changes which alter the relative volume of circulating blood in viscera and muscles, and possibly to a minor degree in the fermentative processes going on in the alimentary tract. The young man who is in perfect health, with powerful heart and deep respiration, can expel the dissolved nitrogen from his lungs far more rapidly than the old, the intemperate, or one who is over-fatigued by excessive labour. The records of caisson works seem to show that men under 20 to 25 years escape, while the percentage of cases increases with age, and is highest for men over 40; that long shifts increase the number of cases; that men who work the air-locks, passing

material through, and undergoing frequent and short lasting compression and decompression, are not affected. The longer the shift the more complete the saturation of the body; the higher the pressure the greater the risks and the graver the symptoms. The records show that practically no cases occur with a pressure below 1½ atm., even though the decompression period be made only a minute or two.

At the Rotherhithe tunnel, now building, the decompression period is 3 minutes, and the maximal pressure + 22 lb. No cases of any gravity have yet occurred. Nevertheless, we have proved that the workers have excess of nitrogen in their bodies after decompression. We have given them a quart of beer to drink in the tunnel 30 minutes before decompression to provoke diuresis, and have made them empty their bladders just before, and again 10 minutes after, decompression. Their urine yielded more than the normal volume of N_2 (1·6 per cent. in place of 1·2 per cent.). The urine, passed immediately after their decompression, obviously effervesced.

The saturation of the body fluids with N_2 probably follows a curve, at first steep in ascent and then slowing off. On decompression the curve of desaturation is probably the reverse—at first steep in descent and then slowing off. Thus we find our urine not saturated with N_2 when we reach say + 3 atm., but becoming saturated in the next 10 minutes. Again, we find on examining, that even after allowing 20 minutes per atm. for decompression, there is more N_2 than normal in our urine. Thus the urine secreted in the next 10 minutes following decompression may contain 1·6 to 2 per cent. in place of the normal 1·2 per cent.

The records of cassion works seem to show that bad ventilation of the caissons increases the cases of illness. Mr. E. W. Moir, in particular, has laid great stress on this, and has attributed caisson illness to excess of carbon dioxide in the air breathed. Snell, the medical officer at the Blackwall tunnel, accepted Moir's views, and said that to avoid caisson illness it is necessary to keep the CO_2 in the air under 0·1 per cent., and this is actually being done now at the Rotherhithe tunnel. To maintain so perfect a ventilation as that means an enormous supply of compressed air, and entails great expense. The vast hall at Rotherhithe full of compressor engines is a most impressive sight.

The work of modern physiologists is opposed to this view (Haldane). Mr. Ham and I have exposed animals in compressed air to a partial pressure of CO_2, equal to 10 per cent. of an atm. Mr. Greenwood and I frequently have no ventilation going in our chamber, because we dislike the noise of the pump, and are decompressed from air containing as much CO_2 as 2 per cent. of an atm. I have breathed comfortably for half-an-hour in a life-saving dress, wherein the CO_2 was allowed to rise to 3 per cent. No harm can result from the breathing of percentages of CO_2 far higher than Snell's figure of 0·1 per cent.

Other sources of the ill results of bad ventilation must be looked to. First and foremost is the possible pressure of carbon monoxide (CO), in caissons where flare-lights, furnaces, and blasting charges are used, or where low-flash oils are employed to lubricate the compressors. CO has an affinity for hæmoglobin 130 times as great as O_2, and a very small percentage may have a marked effect. This effect may not be manifested in the caisson where the partial pressure of O_2 is high, but may first become manifest on decompression. For Dr. John Haldane has shown that animals, whose hæmoglobin is saturated with CO, can live in 2 atm. of pure oxygen. So men with blood one-third saturated with CO would be unaffected in $\frac{2}{3}$ atm. of oxygen, *i.e.* about 3 atm. of air, but would become affected on decompression. If during and after decompression the O_2 supply is diminished by CO, and the heart enfeebled thereby, less N_2 will be given off, and the men may be affected both by want of O_2 and by N_2 bubbles. The immediate success of recompression, which E. Moir has had in recent cases at the New York tunnels, suggests to me that CO may contribute to the numerous accidents there, especially as, Mr. Moir tells me, 20 minutes are allowed for decompression.* He says that the men who use the diving-bells at the Dover works are free from illness, in contrast to caisson workers working at the same pressure. Here again the purity of the air from CO is possibly one of the causes of the Dover immunity.

The excessive heat and saturation of the air with moisture of caisson works induces fatigue. The heat-regulating mechanism, the heart and respiration, is sorely tried in keeping the body temperature normal, while a man is doing heavy work at 80° F.,

*It is very doubtful that the men really stick to this slow rate of decompression.

and in air completely saturated. The loss of sweat is enormous, but this by drying the muscles may be of advantage by lessening the total volume of body water and so of absorbed nitrogen.

Any cause, then, which depresses the vigour of the workman increases his risk from decompression. Hence the beneficial effects of short shifts and ample ventilation.

The men chosen for high-pressure work should be young, spare, and wiry, and in perfect health. The man of spare habit has less water and fat in his body to take up N^2. The man with powerful heart and ample respiration can get rid of the dissolved N_2 most readily. Some men are more fitted than others, as experience shows, but no immunity to caisson illness can be established by habitual work in compressed air.

The experimental results obtained by rapid decompression have unfortunately been amply confirmed on man by the results of explosion of caissons, or the air pipes of divers, on more than one occasion. I recall the case of three workers who were sinking a well in a brewery and working at + 2·5 atm., when the air pipe burst. The men were found dead. On dissection, bubbles of gas were visible in all parts of the connective tissues and blood vessels.

The post-mortem examination of fatal cases of caisson and divers' paralysis are now fairly numerous (v. Leyden, Van Rensselaer, Nikiforoff, Sharpless, v. Schrötter, &c.). They show lesions in the spinal cord, areas of degeneration and actual destruction brought about by bubbles here or there blocking capillaries and cutting off the blood supply. The figures of such lesions (shown on the screen) make evident the terrible risks run by compressed air workers.

SYMPTOMS OBSERVED IN COMPRESSED AIR.

We find the voice becomes high pitched and nasal in tone, and loses its individual character. The pitch rises with the pressure. The fine vibrations of the lips which cause whistling and whispering cannot be produced in the dense air at 4 atm. The mechanism of respiration and the output of CO_2 as far as we have tried them are unaltered, and no noteworthy change occurs in the circulation. To study the respiratory exchange we have used the ingenious method of Geppert and Zuntz (demonstrated), and Haldane's method for measuring the tension

of CO_2 in the lungs. The CO_2 tension regulates the ventilation of the lungs, and we find this regulation continues to act up to 6 atm. There is the same partial pressure of CO_2 in the lungs at 6 atm. as at 1 atm.

We had no sense of the air-pressure and could not estimate its height. Mr. Greenwood, after decompression from 92 lb. suffered from pains in the forearms, which were of some severity and lasted a few minutes. On one occasion I had some small patches of ecchymoses in the subcutaneous fat of the chest. Otherwise, except nervousness, we have endured no symptoms of any note.

THE PREVENTION OF COMPRESSED AIR ILLNESS.

Bert, from his experiments on animals, concluded that all trouble could be avoided by extending the decompression period to 30 minutes for 2 to 3 atm., 60 minutes for 3 to 4 atm.

This ruling of Bert has never been carried out at any of the English or American works, a minute or two (at most 20 minutes) being the usual period allowed for "leaking out." V. Schrötter, from his experiments, concluded that 20 minutes per atm. was a safe period, and I found this to be uniformly safe for a large number of animals which I had exposed to saturation for some hours at a time and for ourselves.

On the Continent the decompression period has been made nearer to that demanded by Bert, but not long enough, and severe and even fatal cases have not been avoided. Thus at the Limfjord works two deaths occurred, the pressure being + 3·5 atm., and the decompression period 45 minutes. At Cubsac there were sixteen severe cases and three deaths, the pressure being + 2 to + 3 atm., and the decompression period 25 to 30 minutes; at Nussdorf two deaths and 43 cases of paralysis, the pressure being + 2·3 atm., and decompression period 25 to 30 minutes. Were these times really kept to?

We have found that our urine contains too much nitrogen even when 20 minutes is allowed for each atmosphere. The time cannot therefore be made shorter than this, if risk is to be avoided. It is especially of importance not to hurry the last atmosphere, because any gas bubbles free in the blood will double their volume on dropping from 2 to 1 atm. (Haldane). This is just the period which the men might think it safe to hurry. I think it important that all parts of the body

should be moved in turn and often during decompression, so as to drive the blood back to the heart, and increase the rate of circulation and depth of respiration.

CAN WORK SAFELY BE EXTENDED TO GREATER DEPTHS?

In caisson works the sickness has been so great at the higher pressures that no engineer has dared to use more than + 3·5 atm. (115 feet). Divers do more than this; the best pearlers and sponge divers reach 140 feet. Lambert salved £100,000 at a depth of 160 feet. Erostabe salved bullion at 171 feet. These men stayed but 20 minutes below at a time, and took 20 minutes to ascend. Lambert was stricken slightly with paralysis after his last ascent, when he had stayed down longer looking for the last box of gold. His companion lost his life.

Hersent experimentally compressed a workman to just over 6 atm. (76·8 lb.) for 1 hour, giving 2 hours 25 minutes for decompression. No ill result followed. I have been compressed to the same pressure, while my colleague, Mr. Greenwood, has reached a pressure of over 7 atm. (92 lb.), corresponding to a depth of 210 feet.

Subsequent to our experiments, Lieut. Damant and Mr. Cato, of the Royal Navy, directed by Dr. John Haldane, have successfully dived to 210 feet. They were exposed to this depth for 15 minutes, then returned rapidly to a depth of 50 feet, stayed there some time, and thence to the surface. The short exposure prevented the saturation of their bodies with nitrogen, and this, in my opinion, made this step method of decompression a safe one. Dr. Haldane holds that if a man rapidly return from +6 atm. to +2 atm. any bubbles set free in his blood are too small to harm him, and escape through the lungs while he waits at + 2 atm. Then he can safely return to + 0 atm. Whether this opinion is a correct one is at present a matter of controversy. I think the method is very good for short exposures for it prevents saturation at dangerous pressures.

THE RELIEF OF COMPRESSED AIR ILLNESS.

Recompression was a method which naturally suggested itself to the earliest workers in caissons (Pol and Watelle, 1854). Bert showed the value of it experimentally, and v. Schrötter, and Macleod and myself have demonstrated the same. In the frog's

web I have seen the bubbles go into solution on recompression, and the circulation may even recommence. If bubbles have formed in the nervous system, the recompression must be carried out quickly, for anæmia lasting some minutes will produce death of the nerve cell. In the case of bubbles embarrassing the heart, recompression may relieve the symptoms immediately and entirely.

Smith, at Brooklyn, and E. W. Moir, at the Hudson tunnel, introduced a recompression chamber, or "medical lock," for the workmen, and Moir has seen many men entirely restored from coma, &c., by recompression followed by slow decompression. A medical lock is now the rule at all works. The men should live in barracks at the works, so that the medical lock may be always at hand, for they often are not affected till some half hour or so after leaving the caisson. If the recompression is delayed it can do little good.

The safety of divers and caisson workers can only be assured by increasing the period of decompression. For pressures above + 1·5 atm. the locking out period should be extended. For pressures of + 2 to 3 atm. I should be sorry to be decompressed at any rate quicker than 20 minutes per atm. The lock should be made a comfortable room, warmed and lighted. The men (during decompression) should carry out muscular movements of all parts of the body, so as to hasten the circulation and carry the blood quickly through the lungs.

A band of men trained in patience to be so decompressed, might carry out tunnelling operations at a depth hitherto not dared by the engineer. For deep-sea divers I have designed a bell which the diver can enter at the bottom of the sea, and in which he can be slowly and safely decompressed after the bell has been raised on deck. With such an apparatus, I believe it will be possible to salvage wrecks at depths of 200 feet.

I now turn to the consideration of the influence of high pressures of oxygen on life. Contrary to preconceived opinion, we find the rate of combustion of an animal cannot be accelerated, as that of a fire can be, by increasing the supply of oxygen. The living tissues set their own rate of metabolism, and neither the inhalation of oxygen nor exposure to compressed air can be used as a therapeutic agent to increase the normal rate of tissue change. It is only cases where the oxygen supply is deficient—

such as severe anæmia, carbon monoxide poisoning, congenital disease of the heart, pneumonia, &c.—where the tissues, and in particular the heart itself, are suffering from oxygen hunger; it is only these cases that can be benefited by oxygen inhalations.

It is a remarkable thing that the continued action of oxygen at a pressure of 1 atm. and over acts as a poison (Bert, Lorrain Smith, L. Hill and Macleod). It produces inflammation of the lungs, depresses the respiratory exchange, and lowers the body temperature; at pressure of 2 to 3 atm. it quickly produces general epileptiform convulsions, and these are followed by a gasping type of breathing, coma, and death. All terrestrial animals, as far as I have tried them, are instantly thrown into convulsions and killed by exposure to 50 to 60 atm. of oxygen.

On the other hand, the excised hearts, muscles, and nerves of frogs, I find, survive the exposure to such a pressure for an hour, although with somewhat abated vigour. The swim bladder of the fish must be immune to oxygen poisoning, for in fish, caught at a depth of 4,500 feet, whose bladder contained almost pure oxygen, the tension at which this gas was secreted was nearly 135 atm.!

The lungs and the nerve cells seem to be the especial points of attack by high pressures of oxygen. It requires, I find, an exposure for about 24 hours at 8 atm. of air (the oxygen pressure = 167 per cent. of an atm.) to produce marked pulmonary congestion; no such result follows if the oxygen in the air be halved by the addition of N_2. Owing to the danger of oxygen poisoning it will not be advisable for men to work for long periods at high pressures. Oxygen at a tension of 180 per cent. of an atm. (equivalent to about + 8 atm. of air or 265 feet depth) kills mice in 24 hours, while at 300 per cent. of an atm. it produces pneumonia in about 5 hours (Lorrain Smith, Hill, and Macleod). Bert showed that inhalation of oxygen will hasten the clearance of dissolved nitrogen. V. Schrötter has recommended deep-sea divers to carry a small cylinder of oxygen and to breathe it for a few minutes before ascending. Now I have found that a cat becomes convulsed in oxygen at 50 lb. in as short a time as 6 minutes. As the size of the animal seems to make no difference to the time of onset, it does not seem safe to employ the suggestion of v. Schrötter. The idea of a diver convulsed at the bottom of the sea is one too horrible to contemplate. Any

diving apparatus, such as the Fleuss, which is fitted with an oxygen cylinder in place of air pump and pipe, is obviously not safe to use for more than a few minutes at any pressures above + 1 to 2 atm. of oxygen.

The Fleuss apparatus (demonstrated) for life saving in mines, &c., has been submitted to me for physiological tests. An enlarged breathing bag and improved face piece, a gauge to show amount of oxygen supply, reducing valve to deliver 2 litres per minute, and emergency valve for extra supply when wanted, have together made this a most valuable instrument. It is one, moreover, which can be used by any workman after a few minutes trial, and is of such strong and simple mechanism that it cannot easily get out of order.

I am indebted to Messrs. Siebe, Gorman and Co. for generously assisting me with apparatus during these researches.

"THE ECONOMIC DESIGN OF HOLLOW SHAFTS,"

By W. E. LILLY, D.Sc. (Member of Council for Irish Districts), of Dublin.

Read 18th October, 1907.

The part played by secondary flexure and its influence upon the proportions adopted for the design of engineering structures is often but dimly recognised. The engineer engaged upon the design of a column, girder, beam or other similar structure is fully aware that the proportions adopted are to a large extent empirical, and recognises that these proportions, being the outcome of a long course of trial and error and sanctioned by experience, are therefore justified in their use. When, however, the reasons underlying these proportions come to be discussed from a theoretical point of view, the problems underlying the influence of secondary flexure must be considered. For instance, take the case of a hollow circular iron column; for a given load and length there is some particular diameter and thickness which will give the best result. If the column is made of large diameter it will be of small thickness and failure will take place by secondary flexure or wrinkling of the side of the column, and if of small diameter and great thickness failure will take place by primary flexure or bending. Hence, for some particular diameter and thickness the column will fail equally by secondary or primary flexure. A column in which the length, diameter and thickness are so proportioned as to obtain this result is called an economic column, and the load it will carry for a given quantity of material is a maximum.

Similarly it can be shown that the proportions adopted in the design of beams are dependent upon the influence of secondary flexure, and that there is a certain thickness and breadth of the flanges compared with the depth which will give the most economic section.

The classic experiments carried out by Hodgkinson, Fairbairn and Stephenson, for the Britannia Tubular Bridge, are perhaps among the earliest attempts to obtain some definite information

experimentally of these economic proportions of engineering structures, and the results then obtained have influenced engineering practise down to the present day.

In some papers* written by the author are recorded a large number of experiments made by him upon circular columns of various proportions of diameter to thickness. It was there shown that some remarkable wave phenomena occur in connection with secondary flexure, and further, that the analysis of these wave phenomena admitted of being simply expressed.

It is not proposed in this paper to consider the experimental work already published, but some reference is necessary to one of the results previously obtained. If a short hollow circular tube be compressed in the direction of its length, the wrinkling or secondary flexure causes the tube to break up into a series of waves, and further, both the experiments and the analysis show that the length of the waves is proportional to the square root of the sectional area of the tube. These results lead to the following equation for the value of the limiting load on one wave length of the tube

$$f = \frac{F}{1 + K\frac{\rho}{t}} \qquad (1)$$

where f = the limiting load in pounds per square inch on a tube of one wave length

F = the strength to compression of the material in pounds per square inch

K = a constant = $\frac{1}{8}$ for mild steel

ρ = the radius of gyration of the circular cross section of the tube about a diameter

t = the thickness of the circular cross section of the tube.

The object of the investigation described in the present paper has been to determine the influence of secondary flexure upon the strength of hollow shafts and tubes under torsion, and indirectly to gain some definite information experimentally of the wave phenomena which accompany it. A similar analysis to that already given in the case of the columns leads to an equation for the limiting value of the shear stress for hollow shafts under torsion corresponding to that given in equation (1), and it is

*Proceedings I.Mech.E., 1905, and I.C.E. of Ireland, 1906.

interesting that the values obtained from these experiments tend to confirm this result.

The experiments were carried out in the Engineering Laboratory of Trinity College, Dublin, on a 10-ton Wicksteed testing machine. The author regrets that owing to the small size of the machine it was not possible to carry out tests on any specimens but those of small sectional area. The range of the investigation has of necessity been limited on this account.

A large number of specimens were prepared and tested. Particulars of the lengths, diameters, gauges and maximum twisting moments of some of these are given in the following tables, and on Figs. 1 and 2 are reproduced photographs of the specimens after they had been tested.

TABLE I. CORRESPONDING TO FIG. 1.

Specimens cut and prepared from solid mild steel shaft.

Length between shoulders 1¼ inches.

Reference to Fig.	A	B	C	D	E
External diameter inches ...	1·81	1·69	1·625	1·58	1·50
Internal ,, ,, ...	1·75	1·62	1·500	1·37	1·37
Maximum twisting moment inch pounds	6800	9640	10480	14040	8620
Reference to Fig.	F	G	H	I	J
External diameter inches ...	1·47	1·36	1·25	1·00	1·06
Internal ,, ,, ...	1·25	1·12	1·00	0·87	0·75
Maximum twisting moment inch pounds	14000	14000	13200	3700	11000
Reference to Fig.	K	L	M	N	O
External diameter inches ...	0·98	0·9	0·84	0·79	0·75
Internal ,, ,,	0·62	0·5	0·38	0·25	0·00
Maximum twisting moment inch pounds	10100	8840	8120	7520	6840

On the lower part of Fig. 1 are shown four specimens (P Q R S) of mild steel plate, 26 S.W.G., tested under a shear stress. The distance apart of edges bounding the wave formation is 1½ inch, 1 inch, ¾ inch and ½ inch respectively.

TABLE II. CORRESPONDING TO FIG. 2.

Specimens cut and prepared from mild steel tubes.

REFERENCE TO FIGURE.	SPECIMENS IN COLUMN.				
	A	B	C	D	E
Lengths 3 ins.	External Diameters.				
	1½ in.	1¼ in.	1 in.	¾ in.	½ in.
S.W.G.	Maximum.	Twisting.	Moment.	Inch.	Pounds.
18 annealed	4400	3000	2000	1300	680
18	6700	4600	2300	1900	820
20 annealed	3100	2500	1400	1040	480
20	4400	3700	2400	1500	660
23 annealed	1800	1430	900	600	300
23	2600	2000	1300	720	440

The dimensions of the remaining specimens shown on Fig. 2, reading from the top, are :—

	Inches.					Inches.			
Diameter	1½	Gauge	20	Lengths	2	½	1	Group	F
,,	1½	,,	23	,,	2	1	½	,,	G
,,	1	,,	23	,,	1½	1	½	,,	H
,,	¾	,,	20	,,	1½	1		,,	J
,,	½	,,	23	,,	2			,,	K
,,	¾	,,	23	,,	½	2	1½	,,	L
,,	1½	,,	23	,,	7			,,	M
,,	1 annealed	,,	23	,,	6			,,	N
,,	1	,,	23	,,	5			,,	O

The method of carrying out the tests was similar to that usually adopted for such tests, and calls for no further remarks.

Stress strain diagrams were taken from some of the specimens, which, however, did not give much information in the present investigation, and will not be further considered. For testing the tubes special grips had to the designed. Two circular dies were prepared, with central apertures corresponding to each diameter of tubing; these apertures were then made slightly oval and coned. The tubes were then expanded into these apertures and secured by means of oval plugs driven into the dies. The specimen was then ready for testing.

The values obtained from the testing of the tubes showed considerable variation. The tubes when they come from the mill are in a state of strain, and when tested in this condition are stronger to resist torsion than when annealed.

In order to enable a comparison to be made, a duplicate tube corresponding to each diameter and gauge was prepared and annealed and then tested. From Table II. it will be seen that the values obtained were in every case lower than those for the unannealed tubes, and also that the values obtained when plotted on Figs. 3 and 4 give the more consistent results. The specimens represented in Fig. 2 were as obtained after testing. It was necessary to cut the tubes at the gripped ends near the shoulders of the dies, and only the central portions therefore are shown. The method of preparing and testing the remaining specimens will be understood from Fig. 1. Being cut from the solid, with the ends prepared to suit the machine, no special grips were required. Tests were carried out to determine the strength of the tubing in direct shear, and an average value of 55,000 lbs. per square inch was obtained; the torsion experiments, however, gave higher values, and an average value of 60,000 lbs. per square inch has been adopted in plotting the curves on Fig 3.

Before proceeding to explain the method of plotting the values obtained from the experiments recorded in Tables I. and II., it is necessary that the formulæ deduced from the theory of elasticity for determining the strength of shafts should be given. The derived formulæ used in the present investigation will then be considered.

The formula for the strength of a cylindrical shaft is

$$M = \frac{S}{r} I \qquad (2)$$

when M = the twisting moment
S = the shear strength of the material
r = the outside radius of the shaft
I = Polar moment of inertia

This formula applies to hollow or solid shafts, and only holds true within the elastic limits. As pointed out long ago, it gives only approximately the value of the breaking twisting moment. For hollow shafts which are of small thickness compared with the diameter, it does not hold true even within the elastic limits, as it does not take into account secondary flexure.

Let ρ be the radius of gyration referred to the polar moment of inertia, then $a\,\rho^2 = I$. Also, let s be the shear stress at the distance ρ from the centre of the shaft, then

$$M = \frac{S}{r} I = \frac{s}{\rho} I = s\,a\,\rho$$

For hollow shafts, which are of small thickness compared with the diameter the value of ρ is nearly equal to the mean radius of the shaft. Let s be the shear strength of the material when secondary flexure is considered. Then

$$s = \frac{M}{a\,\rho} \qquad (3)$$

The values of s shown on the vertical ordinates of Fig. 3 have been determined from the experiments by means of this formula. For the solid sections and for those sections approaching the solid, correct values of ρ were calculated.

The values of s having been thus obtained and plotted on Fig. 3, curves were plotted to the equation

$$s = \frac{S}{1 + k\frac{\rho}{t}} \qquad (4)$$

where s = shear strength of material when secondary flexure is considered
S = shear strength of material 60,000 lbs. per square inch for mild steel
ρ = radius of gyration
t = thickness
k = a constant

After a series of trials the two curves shown on Fig. 3 were decided on. Of these, the equation of the lower curve for the annealed tubes is

$$s = \frac{60,000}{1 + \frac{1}{15}\frac{\rho}{t}}$$

and for the upper curve for the unannealed tubes the equation is

$$s = \frac{60,000}{1 + \frac{1}{30}\frac{\rho}{t}}$$

In plotting the curves it will be noted that the limiting value of $\frac{\rho}{t}$ for the solid shaft is $\frac{1}{\sqrt{2}} = 0{\cdot}7$ and for values which approach the solid $\left(\frac{\rho}{t} - 0{\cdot}7\right)$ should be substituted for $\frac{\rho}{t}$ in the above equations. For large values of $\frac{\rho}{t}$ the 0·7 is negligible.

It will be seen that the values given by the curves agree fairly well with those obtained from the experiments, and that the form of equation (1) applies to the case of hollow shafts when secondary flexure is taken into consideration.

Now substitute for s in equation (3) from equation (4). Then for hollow circular shafts

$$M = \frac{S\,a\,\rho}{1 + k\frac{\rho}{t}} \qquad (5)$$

If ρ is the mean radius and t the thickness, then $2\,\pi\,\rho\,t = a$ and substituting for t in equation (5)

$$M = \frac{S\,a}{\frac{1}{\rho} + \frac{2\,\pi\,k\,\rho}{a}} \qquad (6)$$

Let M and ρ be the variables in this equation; then on differentiating, the condition obtained for a maximum is

$$\rho^2 = \frac{a}{2\,\pi\,k} \text{ or } k = \frac{t}{\rho}$$

Substituting this result in equation (6) the equation for the shaft of maximum strength is obtained

$$M = \frac{S\, a^{\frac{3}{2}}}{2\sqrt{2\,\pi\, k}} \qquad (7)$$

The curves shown on Fig. 4 have been plotted from equation (6) in the following form

$$M = \frac{S\, a^{\frac{3}{2}}}{\sqrt{2\,\pi}}\;\frac{\sqrt{\frac{\rho}{t}}}{1 + k\frac{\rho}{t}}$$

The value of k for the upper curve for the unannealed tubes $= \frac{1}{30}$, and for the lower curve for the annealed tubes $= \frac{1}{15}$. The area of the cross section a was assumed to be constant and equal to 0·44 square inch. In carrying out the experiments it was not possible to observe this condition, the areas of the cross sections of the majority of the specimens shown on Fig. 1 are approximately constant and equal to 0·44 square inch; but of the tubes the areas of the cross sections varied, and in order to plot the values obtained from the experiments on Fig. 4 on the assumption of constant cross section, the values for similar values of $\frac{\rho}{t}$ were corrected by means of the formula $\frac{M_1}{M} = \left(\frac{a_1}{a}\right)^{\frac{3}{2}}$

The values obtained from the annealed tubes agree fairly well with the plotted curve. The curve at first rises rapidly and then afterwards for values of $\frac{\rho}{t} > 7{\cdot}0$ it becomes very flat, showing that little is to be gained in the torsional strength by taking larger values of $\frac{\rho}{t}$. The author is of the opinion that this curve gives the best average results of the investigation. The values of $\frac{\rho}{t}$ obtained give a small thickness compared with the diameter for the maximum torsional strength. This is to be expected when the manner of testing is taken into consideration, the specimens being subjected to pure torsion and the effect, as far as possible, of all other kinds of stresses being eliminated. The results of the investigation, however, show that some economy would be gained in practise by using greater values of $\frac{\rho}{t}$ than usual at present. If the effect of bending and alternating stresses be

taken into consideration, it is probable that the value of $\frac{\rho}{t}$ for the economic section in practise would be somewhere about 3·0 and even with this value, the outside diameter of such hollow shafts would be unduly large and would only be used in special cases. One objection to the use of such shafts of large diameter is the work that would be absorbed in friction at the bearings, and in endeavouring to keep this as small as possible some sacrifice must be made in the design of the shaft.

The influence of the secondary flexure upon the wave formation has been of interest. For the tubes of the larger diameters shown on Fig. 2 the wave forced out is smaller than for the thick tubes of the same diameter. This is a similar result to that established in the case of the secondary flexure of columns.

In carrying out the tests on the longer lengths of tubing only, two waves are shown as being developed on opposite sides of a diameter. It is to be noted, however, that at the instant of the development of the wave, there are a number of spiral waves on the surface of the tube, but that only two of these appear. In the case of long tubing, the number of these waves depends on the square root of the cross sectional area, a similar analysis to that given in the case of columns leading to a similar conclusion.

The three spiral waves shown on the three specimens on the right hand side of Fig. 2 were obtained by inserting tubes within the tube about to be tested. The reinforcement prevents the deformation exceeding a small amount, and on being tested the spiral wave is developed along the length of the tube. The object of these experiments was to obtain some information of the pitch of the developed spiral waves. The effect of the length of the tube upon the number of waves was also considered, and for this purpose a number of tubes of different lengths were tested. Some of these are shown on the right hand side of Fig. 2. From an inspection of these it will be seen that the number of waves increases as the tube gets shorter. This result was expected, and shows that for short lengths the number of waves depends in some way upon the length. Further experiments are required before any generalisation can be made.

The following experiments are of interest as having a direct bearing on the results just mentioned.

On the lower part of Fig. 1 the waves developed in some mild steel plates under a shear stress are shown. The plates were firmly secured between two pairs of flat parallel bars at varying distances apart. For the specimens shown on the figure the distances were ½ inch, ¾ inch, 1 inch and 1½ inch. The bars were then pulled in opposite directions in the testing machine. The results obtained show that in this case the number of waves developed depends upon the distance apart of the bars. The study of these waves and their effect upon the strength of the webs of plate girders was discussed in "Engineering," 1st February, 1906.

The development of these waves in plates and thin tubes of large diameter has another bearing of great practical interest in the phenomena of the collapse of plain cylindrical furnaces. When failure takes place, lobes or corrugations are formed, and it has long been known that the number of these lobes or corrugations depend in some way upon the length, diameter and thickness of the furnace.

Recently, in a long and laborious investigation, Professor Stewart, of Pittsburg, Pa.,* has conducted an admirable series of experiments on the collapse of long cylindrical tubes under external pressure. His results show that their strength depends upon the diameter and thickness. This is an analogous result to that obtained by the author in the published work on columns and in this paper, and it seems as if the ratio of the diameter to thickness must be considered as being of the correct form when applied to such investigations. Further experiments, however, are required to determine the way in which the length affects the above ratio.

In conclusion, the author hopes that these experiments, imperfect as they are, will have the result of drawing the attention of Junior Engineers to the study of the phenomena of secondary flexure. It is hardly too much to say that in most engineering structures it has a very great influence upon the proportions adopted in economic design. Hitherto it has been rather to the eye of the engineer than by direct deductions from theory that these proportions have been attained, and for that reason alone the subject is worthy of further investigation.

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* Transactions of the American Society of Mechanical Engineers, Vol. XXVII.

Discussion.

MR. H. P. PHILPOT in proposing a vote of thanks to the Author for his paper referred to the great interest which Professor Lilly had taken in the Institution for so many years, during the latter as a Member of the Council. He had travelled specially from Dublin for the purpose of presenting his paper *in propriâ personâ*, and the cordial acknowledgments of the members were due to him for dealing with a difficult subject in such an extremely interesting manner. With regard to Figs. 3 and 4, at the end of the paper, Mr. Philpot thought that when the results of two series of experiments were plotted on the same diagram, the points obtained should be recognisable in their particular groups. The same mark, a dot, had been used for both the annealed and the unannealed specimens, and it was therefore not easy to judge how far the curves given represented each set of bars. This might not seem very important, but the usefulness of the diagram as a test of the equations would have been much greater if the results for each series had been rendered distinguishable by the use of say a small cross for the annealed, and a dot for the unannealed bars. From the diagram it was not possible to see whether or not some of the upper dots might not refer to the lower curve. The paper dealt entirely with the economic design of shafts from the point of view of economy of material, and was a very valuable contribution on this subject, but he would like to say that this was not quite the standpoint from which a practical designer would look at the problem of the economic design of shafts. His economic design would be that which gave him economy of cost. Thus it would not generally be found good design to introduce shafts of large diameter and thin material, and it was only in such shafts that secondary flexure would occur. It appeared to him that the value of the paper lay in the fact that it showed the limiting values of $\frac{\rho}{t}$ at which this effect became important.

MR. EDWARD GOFFE, seconded the vote of thanks with great pleasure, and felt that the paper, consisting as it did of the data of a considerable series of tests, with deductions therefrom by the autnor compared with the results obtained by reasoning on principles, was not open to criticism without the fullest possible consideration being given to it, with the conclusions drawn from

the application of the formulæ to actual examples, taken into account.

MR. M. T. ORMSBY, as a visitor, desired to thank the Institution for the invitation to attend the meeting, and was glad of the opportunity it gave him to congratulate Professor Lilly on the capable and energetic manner in which he had attacked the difficult and important subject of secondary flexure. He understood from the paper that the experiments referred to had all been conducted on shafts of the same length. The photographs showed little or no signs of secondary flexure in the thicker tubes, and as he understood that the wave length depended on the thickness, it appeared to him quite conceivable that a longer shaft of the same thickness might fail in this way, even though a tube so short as not to admit of the formation of a complete wave might show no signs of the phenomena in question. He would be glad to know if any experiments had been made on longer tubes, or if Professor Lilly proposed to make any. A question which interested him very much and which he thought was connected with the subject of the paper, was the strength of riveted joints with respect to their resistance to failure by bearing. The usual method of calculation was to multiply the thickness of the plate by the diameter of the rivet, and then by some assumed safe stress. He had been making some enquiries and it seemed to him that engineers in practice adopted very different values for this safe bearing stress. He was inclined to believe, though he thought that Professor Lilly had not specially mentioned the point in his paper on plate girders,* that there was a possibility of failure of the plate by secondary flexure just behind the rivet, and that the thickness of the plate ought to be taken into account otherwise than in the simple method of working just mentioned. The question was, if two plates, one half the thickness of the other were subjected to bearing stresses, all other things being equal, would the thin plate carry just half as much as the thick. He was inclined to think it might fail sooner by secondary flexure. Whether this accounted at all for the discrepancy in the values adopted he was unable to say, but he thought that at University College, London, they would be making some experiments soon on this point. He trusted that similar experiments would be made elsewhere.

*Transactions of the Inst.C.E., Ireland, 1907

MR. W. H. SHEPHARD said the subject of the paper was a most important one, and the Institution had had the privilege of having placed before it certain formulæ for struts which apparently were not available to the engineers who designed the Quebec Bridge. Referring to Fig. 3 he asked whether the curves were calculated or drawn freehand in the best position through the points obtained by the tests.

PROF. LILLY replied that they were obtained by calculation.

MR. SHEPHARD, continuing, thought it would be very desirable to have the various formulæ for struts which appeared on one of the lantern slides reproduced in the Transactions, as they would be valuable for comparison and reference. The simplicity of the author's formulæ was very welcome. Of course it had reference to cylindrical struts only, and this pointed to the advisability of using such a section for compression members of important structures, rather than more complex sections of which so much was not known.

MR. JOHN CLEGG also asked if the formulæ for struts could be given in the Transactions. He had no doubt there were other members like himself who took a special interest in the calculations involved in designing them.

MR. GEORGE GENTRY pointed out that, while such close theoretical results as were recorded in the paper were extremely interesting and valuable for reference purposes, the practical engineer was confronted with the problem of economic general design. As an illustration he cited an imaginary case of the design of a long propeller, or other shaft, in which, using such formulæ as had been given in the paper, one arrived at the most economic section of hollow shaft whereby a fair proportion of steel was saved as compared with a solid shaft, but in which the saving of the steel account was more than wiped out by the extra cost of gun metal, and cast iron necessary for suitable bearings. It appeared to him that the true economy of design lay somewhere between the most economical form of shaft and the most economical form of bearing, and so on for all parts of a piece of apparatus. In the case of a short shaft, where the loss in such as bearings would be but little, the corresponding gain in the matter of steel for the shaft would be so small that the use of such accurate formulæ would be scarcely necessary.

PROFESSOR LILLY in replying said it was very gratifying to him

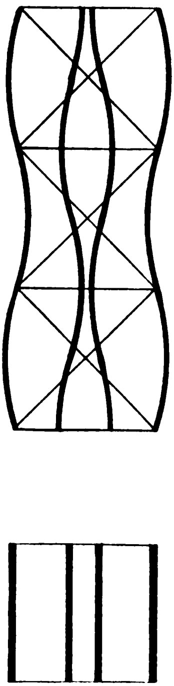
to be able to be present again at a meeting of the Institution, and to note the immense strides the Institution had taken since the early days of his active membership. He thanked the members for the very kind way in which they had received his paper. With regard to Mr. Philpot's remarks it would perhaps have been better if some distinction had been made in the plotting of the results of the experiments on the annealed and unannealed tubes. The results obtained and the method of calculation, however, were fully given in the paper, and little difficulty would be found in distinguishing between the experiments as plotted.

Both Mr. Philpot and Mr. Gentry had referred to the question of cost. It was to be remembered that the object in view in carrying out the experiments had been to determine the economic ratio of the diameter and thickness of a hollow shaft to transmit a given twisting moment. He was quite aware that cost was a primary consideration from the practical engineer's standpoint, but in investigations of this kind such considerations must of necessity be left in abeyance. It was for the engineer afterwards to see what use could be made of them.

Mr. Ormsby had referred to the lengths of the specimens that had been tested. Before deciding on the length of the specimen used in the experiments recorded, various lengths were tested, and it was found that when the length exceeded about three diameters little variation took place in the torsional strength. With lengths less than this, the influence of length upon the secondary flexure required to be taken into consideration. The analysis under these conditions became very troublesome, and, as mentioned in the paper, it would be a matter for further investigation to determine in what way the length influenced the torsional strength.

The experiments had been carried out mostly on circular sections. He would point out, however, that with different values of k, equation (4) could be used for other cross sections. Experiments showed that the value of k was least for the circular sections, and this was to be expected. A great deal of experimental work was yet required to be done before precise values could be given to k for other sections.

The formulæ for struts referred to by Mr. Shephard and Mr. Clegg had already been published in papers given by him to the



Institution of Civil Engineers of Ireland in 1906 and to the Institution of Mechanical Engineers in 1905. Copies of them would be found in our Library. He had shown that secondary flexure played an important part in the failure of struts and hollow shafts. There seemed to be little doubt that the failure of the Quebec Bridge was directly traceable to this cause. In the accompanying sketch was shown a short length and cross section of the chord member of the bridge which failed. On testing such a short strut the side would tend to develop into a wave form. If the bracing was of small cross section compared with the side, it would not be of sufficient strength to resist the wave deformation. The bracing would then fail, and the strut collapse, and this was probably the manner in which the chord member of the Quebec Bridge failed with such disastrous results.

MR. H. H. THORNE, reporting the discussion at Coventry, writes: It was felt at first by some that the subject was, if one may use the term, outside the scope of practical engineering, but before the proceedings concluded, it was agreed that it touched on principles which are of great importance to every engineer. It was pointed out that, while the samples used in the tests were so small as to make the results appear of little value, if absolutely reliable data were to be obtained, yet the results were such as to compel one to admit that some of our previous conceptions of the economic design of shafts were very much at fault; in fact, that in our work hitherto no consideration appeared to have been given to it. Those present felt that they were much indebted to the men who spent both time and thought in carrying out experiments connected with such subjects as the one under discussion; subjects which the average engineer had not the opportunity to thoroughly investigate himself, but on which it was necessary that he should have reliable data to enable him to do good work. The evident labour which had been devoted by Dr. Lilly to the preparation of his paper was appreciatively acknowledged, the only regret expressed being that it did not contain the results of tests on similar shafts under different kinds of stresses.

ECONOMIC DESIGN OF HOLLOW SHAFTS.

Fig. 1. Photographs of Specimens.

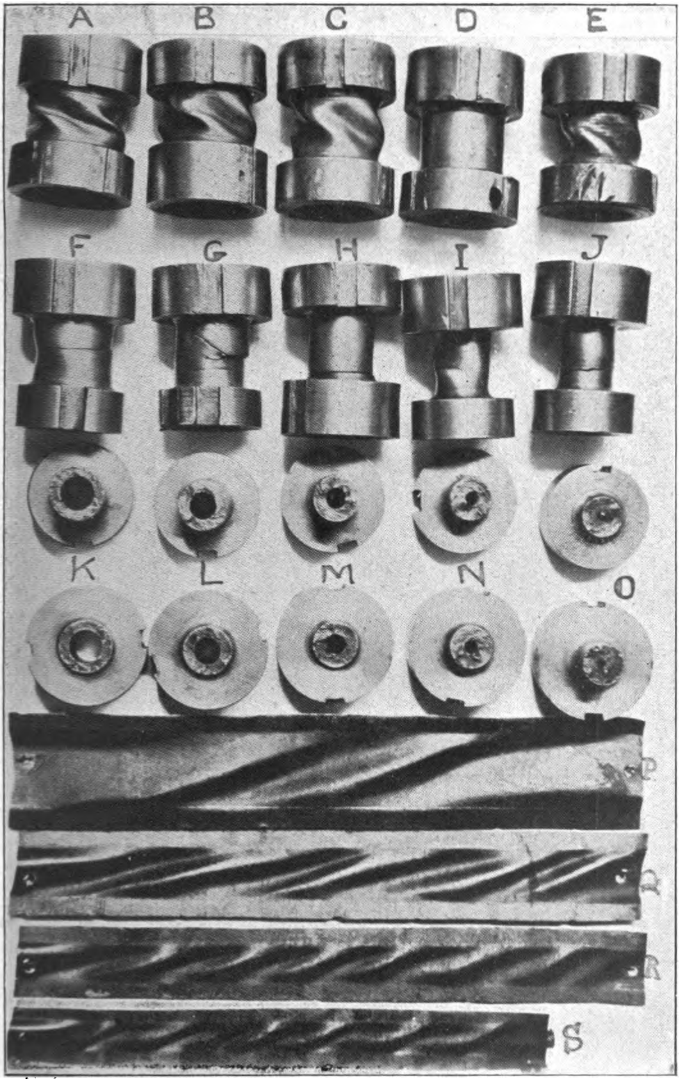


PLATE 2.

ECONOMIC DESIGN OF HOLLOW SHAFTS.

Fig. 2. Photographs of Specimens.

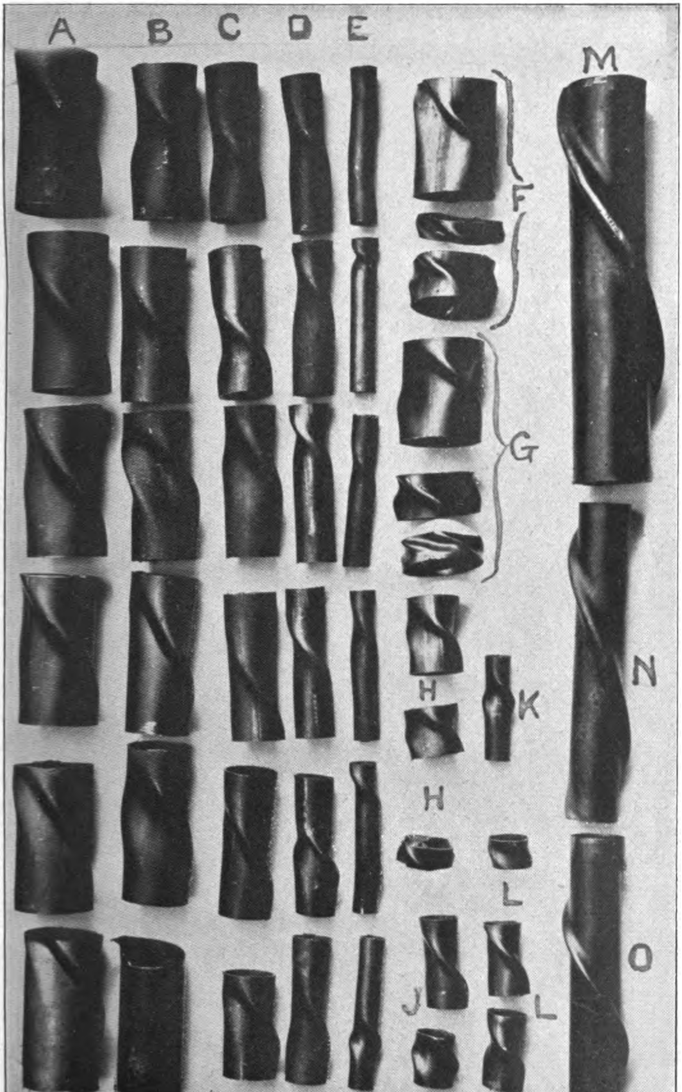
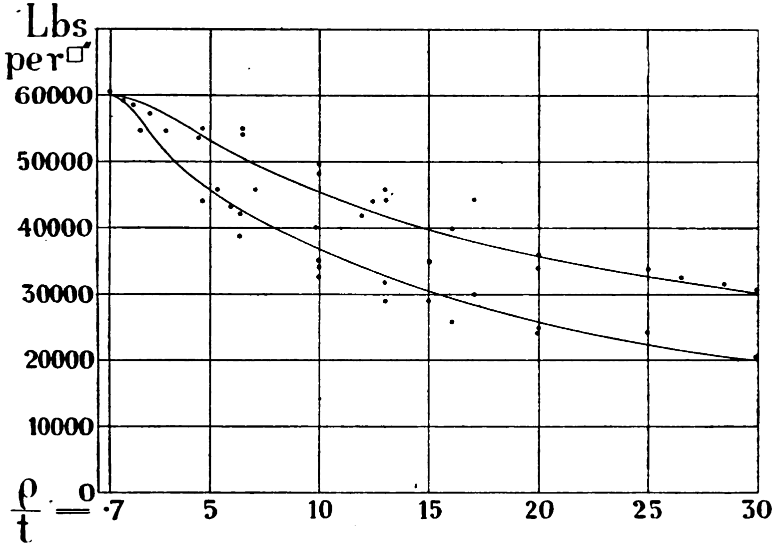


PLATE 3.

ECONOMIC DESIGN

OF HOLLOW SHAFTS.

Fig. 3.



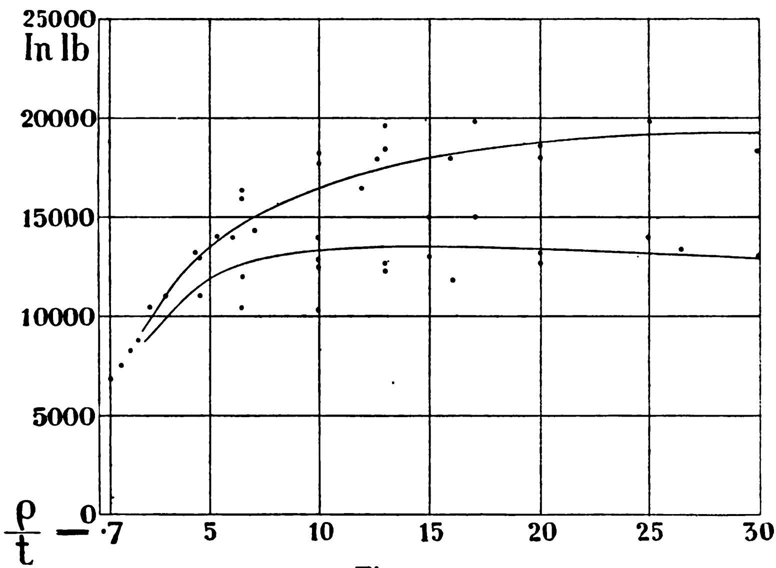


Fig. 4.

Part 3. DECEMBER, 1907. Vol. XVIII.

The Junior Institution of Engineers
(Incorporated).

President - - M. GUSTAVE CANET.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

3rd December, 1907.

ANNOUNCEMENTS.

TUESDAY, 10th DECEMBER. Meeting at 8 p.m., at which a Paper entitled "**Notes on Arc Lighting**" will be read by MR. WILLIAM KRAUSE (*Member*).

SPECIAL NOTICE.—It having been found necessary to arrange for another place of meeting, with the kind permission of the Council of the Society of Arts, the above meeting will be held at the Rooms of the **Society of Arts, John Street, Adelphi** (turning from Adam Street, Strand).

SATURDAY, 14th DECEMBER, at 3 p.m. Visit: The Franco-British Exhibition Buildings, &c., in process of erection at Shepherd's Bush, for inspection of features of constructional engineering interest; **The Exhibition Extension Works of the Central London Railway**; and **The Central London Railway Power House,** at Shepherd's Bush. Admission **at 3 p.m.** at the Wood Lane Second Entrance of the Exhibition on production of Badge of Membership.

WEDNESDAY, 8th January, at 8 p.m. Paper on "**Recent Improvements in Electric Conduit Traction Construction,**" by MR. FITZROY ROOSE, L.C.C. Tramways Reconstruction Department.

SATURDAY AFTERNOON, 11th January, at 3 p.m. Visit: London County Council Tramway Reconstruction Works in course of progress in South Lambeth Road; and the **Camberwell New Road Depôt and Sub-station.** Members to assemble **at 3 p.m.** at the corner of South Lambeth Road, opposite Stockwell Station of the City and South London Railway. They will proceed towards Vauxhall Station, taking tramcar there for the Camberwell Depôt.

PERSONAL NOTES.

G. BERGMANS has commenced practice with Mr. H. Lancaster Hobbs, at 5 Copthall Buildings, E.C., as Consulting Mining Engineers and Metallurgists.

S. BLAKENEY has been appointed Chief Assistant to the Resident Engineer to the L. and N.W. Ry. Company's Euston to Watford Electric Railway, contract No. 1. Address, 26 Harley Road, Harlesden, N.W.

ERIC F. BOULT has joined the editorial staff of "The Autocar," Coventry.

FRANK R. DURHAM. The business of Robert Warner and Co., of London and Walton-on-the-Naze, which has for some time past been carried on by the executors of the late Robert Warner, has now been registered as a joint stock company under the title of Robert Warner and Co. (Engineers), Limited. Mr. F. R. Durham is now associated with this company as managing director, and Mr. G. H. Hughes has been appointed works manager.

FRANK D. EVANS has secured an appointment as Assistant Engineer in the Public Works Department of the Federated Malay States, and sails for Penang on 14th December.

CHARLES RICHARD HARRISON, recently elected to the Institution, returns to Singapore, Straits Settlements, this month.

A. R. HAYWOOD, previously with the Great Central Railway Co. at Chester, has gone to Argentina, address—Ferro Carril, Buenos Aires y Pacifico, Bahia Blanca.

GEO. H. HUGHES. [See note above *re* F. R. Durham.]

C. J. INDER left for West Africa on 20th November, to report on some gold dredging work on the Upper Gambia and Senegal Rivers, and expects to be away about five or six months.

REGINALD JOLLIFFE has been appointed Surveyor's Assistant to Messrs. Thomas Wood and Sons, Engineers and General Contractors, Swanley, Kent.

J. JULIAN, who passed the final examination for the B.E. degree of the Royal University of Ireland at midsummer, was admitted to the degree on the 1st November.

WILFRID MATTHEWS writing on SS. "Indroghiri" in port at Adelaide, S. Australia, under date 27th October, mentions having, when at New York, called on Mr. Woodroffe Manton (*Member*), who showed him over the East Rivers Tunnels Construction Works, during which he had his first experience of being under air pressure. He continues: "I used to think that in the British fireman we marine engineers had a very awkward person to deal with, but now I must say I have seen worse. Mr. Manton

and his assistants have labourers amongst whom twenty different languages are spoken—a regular Babel." Mr. Matthews expects to be home about Christmas time, and is returning via Suez, Port Said, Malta, Gibraltar and Dunkirk.

JOHN MCCLURE, appointed Assistant Engineer on the New Harbour Works, Para, being carried out by the Para Construction Co., sailed on 8th November, from Liverpool, by SS. "Clement," of the Booth Line. Address: Box 469 Para, Brazil.

WALLACE MCMULLEN expects to be home from Rangoon early in the new year.

R. W. PFENNINGER has been appointed lecturer in Engineering at the L.C.C. Paddington Technical Institute.

T. A. ST. JOHNSTON has left Chingford to take up an appointment in the West Ham Corporation's Electricity Supply Department.

J. WESTON is now engaged in the drawing office of the Cubitt Concrete Construction Co., of London.

HAL WILLIAMS has sailed for New Zealand, for a visit home—c/o Dr. J. W. Williams, Gisborne, North Island—and is expected back in England about the end of February.

Appointments.

211. Member, age 28, desires engagement as draughtsman. Thoroughly acquainted with machine tools, small tools, jigs and fixtures.

212. Member, age 32, seeks temporary position in mechanical engineer's drawing office. Has had varied experience.

Changes of Address.

BARSON, J., 1 Pondswicks Road, Luton.

BENTALL, A., "Holts," Upper Mildmay Road, Chelmsford.

BENYON, G. A., 16 Laurel Bank, Halifax.

BOOTHROYD, A. W., c/o H. W. Bamber, 25 Ryder Street, W.

BULLOCK, GEO. T., Chief Surveyor, Union Assurance Society, Ltd., 1 and 2 Royal Exchange Buildings, E.C.

CATTERSON, C. E., 80 Barcombe Avenue, Streatham Hill, S.W.

COX, W. J., 24 Church Crescent, South Hackney, N.E.

DENSLEY, A. R., 12 Station Street East, Coventry.

DODD, G. S., 36 Chelverton Road, Putney, S.W.

DOWNES-SHAW, A. H., 8 Gordon Villas, Dighs Avenue, Worcester.

FISHER, R. W., 66 Browning Road, Manor Park, Essex.

FOSTER, H. P., "Withens," Rainville Road, Bramley, Leeds.

FREEMAN, R., c/o Sir Douglas Fox, Cross Keys House, 56 Moorgate Street, E.C.

GOULD, H. T., Cleveland House, Royal Buildings, Penarth, Cardiff.

HENDERSON, J., c/o Mr. D. D. Henderson, Meadow Lodge, Honor Oak Park, S.E.

HICKS, W. J., "St. Bernards," 156 Plashet Grove, East Ham, E.

HULETT, C. G., 90 Lansdowne Road, Clapham, S.W.

HUTT, A. CYRIL, 4 Park Place, Greenwich.

HYNK, H. E., "Mayville," Stevenston, Ayrshire, N.B.

LIGHTFOOT, E. J., 20 St. George's Avenue, Tufnell Park, N.W.

MILLER, F. S., 40 Chaucer Road, Bedford.

MOORE, F. W., 68 Jackson Street, Gorton, Manchester.

PHILLIPS, W. A., c/o Rev. C. E. Copinger, Audley Road, Hendon, N.W.

PRINCE, W. B., 227 Franciscan Road, Tooting, S.W.

PUDDEPHATT, E. O., 25 Beulah Street, Harrogate.

ROBBINS, C. J., 27 Munster Road, Fulham, S.W.

ROBERTS, E. D., 140 Windmill Street, Gravesend.

SANDERS, H. R., 3 Cardigan Road, Richmond.

SIEVERS, P. H., 147 Abbey Road, N.W.

WALKER, H. M., 31 Lindisfarne Terrace, North Shields.

WHITTAKER, H., 31B Tamworth Street, Fulham.

WILKINSON, A. R., 32 Bonneville Gardens, Bonneville Road, Clapham Park, S.W.

WRIGHT, W. J., 110 High Street, Marylebone, W.

YORGAN, J. A., 376D St. Antoine Street, Montreal, Quebec, Canada.

Library.

Since the last announcement, the following have been added to the Library :—

Australia, Western, Geological Survey, Bulletin No. 24; from the Agent-General for Western Australia.

Automatic Machines, Report No. 35, British Standard Specification for Copper Alloy Bars for use in ; from the Engineering Standards Committee.

Electric Signalling on the Midland Railway ; from Messrs. Siemens Bros. and Co.

Electric Supply Meters, British Specification for Consumers; from the Engineering Standards Committee.

Electrical Machinery, Report No. 36; from the Engineering Standards Committee.

Engineering Standards Committee, Third Report on Work Accomplished ; from the Committee.

Fire Extinguishers, Report No. 121, Fire Tests with; from the British Fire Prevention Committee.

Hydrants, Report No. 123, Fire Tests with; from the British Fire Prevention Committee.

Kimberley District, Prospects of obtaining Artesian Water in the, by Mr. R. Logan Jack; from the Agent-General of Western Australia.

Manchester Municipal School of Technology, and Municipal School of Art; Calendar for the Session 1907-8.

Naval Architects, Institution of, Volume 1907, Transactions; from the Institution.

North East Coast Institution of Engineers and Shipbuilders, Volume XXIII., Transactions; from the Institution.

Pilbara Goldfield, Third Report on the Geological Features and Mineral Resources of, by Mr. A. Gibb Maitland; from the Agent-General for Western Australia.

Railway Points and Signals, Electrically Operated; from Messrs. Siemens Bros. and Co.

Railway Signalling, Mercury Contact Treadle for; from Messrs. Siemens Bros. and Co.

Rhodesia Chamber of Mines (Incorporated), Bulawayo, Twelfth Annual Report, 1907; from the Rhodesia Chamber of Mines.

Royal Cornwall Polytechnic Society, Seventy-fourth Annual Report; from the Society.

Screw Threads, Report No. 38, on British Standard Systems for Limit Gauges; from the Engineering Standards Committee.

CHAS. H. SMITH,
Hon. Librarian.

The Patents and Designs Act, 1907.—A very useful book dealing with the New Patent Act and published by Messrs. Butterworth and Co., of Bell Yard, has just come under our notice. It is the joint work of Mr. James Roberts, Barrister-at-Law, a gentleman who is already the author of several publications dealing with like subjects, and Mr. Fletcher Moulton, who is also a Barrister and will be recognized as the son of our Past-President, Lord Justice Fletcher Moulton, the greatest living authority on the Patent Law. As our members are aware, the new Act has changed the law as to the rights and duties of patentees and owners of designs to an extent which no previous Act has done. This book is intended to be a guide to patentees, their advisors and the general public. It examines and interprets various provisions of the Act, some of which we cannot but realise are obscurely worded. The book is divided into two parts, the first dealing with the obtaining of, and the manner of dealing with, patents under the new law. The second part deals with the text of the Act, and critically examines the effects of the changes introduced.

We notice also that our member Mr. Arthur H. Stanley has contributed an article on the subject appearing in the current number of the Royal Automobile Club Journal and Motor Union Gazette, in which he compares the new Act with the old, pointing out the distinguishing differences.

FROM THE STARTING PLATFORM.

MOTOR BOATS AND MOTORS. I think that one of the most remarkable things about the Motor Boat this year is its "disappointingness," if one may coin a word; this reference I make only in regard to the speed question, and that is, after all, the point about which probably the most fuss has been made by those interested. For example, in 1905 the "Dubonnet," a 49 foot boat, was said to have done a speed of 29·35 knots over a flying kilometre in the Coupe de Paris. Then in 1906, a little 26 foot boat was said to have covered a distance of 81 sea miles in two minutes over the three hours, a speed of just over 26¾ knots. This record was generally accepted at the time as accurate and authentic, although the accuracy of the distance was queried by myself in an article in the "Motor Year Book," 1906.

Now with such speeds obtained at that date, surely we might reasonably expect very much higher speeds in 1907. Certainly at Monaco we were told of them, the 30 knots having been exceeded on paper, but as it was afterwards admitted that the course was short, the whole value of any records obtained there is less than nothing. The only trials which I would care to pin my faith to are those carried out by the "Motor Boat" at Greenhithe this year—the British International Cup course being notoriously inaccurate—and here we find that "Daimler II." was only able to show a speed of 25·72 knots as a mean of six runs, or 25·77 knots as a mean of the best pair.

"Dixie," the American champion boat, appears to be about half-a-knot faster than "Daimler II.," so that we have only 26¼ knots for a 40 foot boat on a short run in 1907 as against 26¾ knots for a 26 foot boat on a three hours' run in 1906! Inaccurate timing or measurement of distance is, in my opinion, the solution, not slower boats, and it seems to me to indicate that we can place no reliance whatever on the extraordinary high speed claims which have been made for motor boats, and that we have been entirely misled.

This cannot be for the good of the industry, and must surely re-act adversely on all concerned. The truth of the matter is I think, that in many cases, especially abroad, the organisation of races has been in the hands of those who have not been accustomed to obtaining accurate measurements of speed, and do not realise the need for absolute accuracy or the great difference a

few yards in the length of the course, or a few fifths of a second in the times, or a bit of tide, make to the speed of a fast boat.

If a further instance were needed, I could quote the "Flying Mile" of the "Rose-en-soleil," Lord Howard de Walden's steam racer, at Liverpool, in 1906, when she was credited with a speed of 27¼ knots! I was on board at the time, and I also clocked all her speed trials when she was being tuned up, and I know she could not do better than 24½ knots, and was not doing it then. I make rather a point of this, as I feel strongly that unless the motor boat is handled properly (in a commercial—not a nautical sense) and more regard paid to accuracy in making claims, the future of the industry will be more retarded than helped.

Extravagant proposals have been put forward that internal combustion engines ought at once to be installed in our destroyers; one party has even gone so far as to prepare designs of a battleship so fitted, and pointed out the enormous advantages that would follow. Quite so, but unfortunately, such people have not taken into consideration the great size of the units necessary for such an installation. Up to the present we have no prospect of units fit for more than a torpedo boat, and even that means five or six sets of engines. The step from that to a battleship is a very great one, and it must not be forgotten how enormously the internal stresses increase with the increase in size of cylinder, to say nothing of the difficulty in getting rid of the great heat of combustion.

What I have said up to the present has been entirely in the nature of growls, and intentionally so, as I have always felt that the industry in which I was very early interested, and in which I still take a deep interest, in spite of, or I may say in addition to my steam interest, is not having a fair chance. Sound industrial progress has always been made by sound productions, and not by inaccurate statements of performances and "gas," although it would appear that the latter must still effectually play an important part in the industry in question.

To turn to a less captious view of the subject, I think that the motor has made useful progress in various fields of marine service. For instance, as auxiliary power in yachts, which, in my opinion, is the ideal application, considerable advance is noticeable, and it is now no uncommon sight to see a large sail-

ing yacht coming into the harbour where I live, in a flat calm or against a strong ebb tide, either under her own power or with the help of her motor dinghy. The reason I single this out as the ideal field is that for yacht purposes no reversing gear is needed, so that the motor can be got into less space than that which would be required for a steam engine, and moreover, if the engine breaks down for any reason, the boat is in no worse a position than she was before the motor was installed ; if there is a breeze she can get along, if there is none, she drifts about or anchors as before.

There is a very interesting installation on one craft that makes the port of Dartmouth her headquarters. This boat is a 46 ton ketch, and the motor, a two-cycle single cylinder 10 H.P. job, is installed on deck just abaft the mizen, where it occupies a deck space of about 20 inches by 30 inches, the petrol tank and all the ignition gear being fitted under the motor casing. The propeller is a solid two-bladed one of 22 inches diameter on a shaft at a considerable angle to the horizontal, but coupled by means of a universal joint to a short piece of horizontal shaft. On this latter and on the motor shaft are chain sprockets, from each of which a chain leads diagonally to a pair of similar and equal sized sprockets, rigidly connected together on a sliding bracket in the starboard bilge. Originally, a vertical chain drove down on to the horizontal shaft direct, but the oscillations, having no gravity as on a horizontal bicycle chain to steady them, were so severe that the chain was constantly breaking. This installation has been a great success, giving the boat a speed of about 4 knots and only takes up a small amount of deck space together with a small portion of the sail locker.

Some progress has also been made with the installation of motors in fishing boats, though I do not think that the case is yet clearly proved either one way or the other as to the financial success.

I always hesitate to prophecy, as so many prophets have had their reputation ruined when venturing to predict the failure or success of mechanical features, but I cannot help thinking that if the industry is properly handled, and its possibilities not exaggerated by enthusiasts, the internal combustion engine will have an important effect on naval construction.

BASIL H. JOY.

OBSERVATIONS IN GENERAL.

The November meeting of the Institution is always a notable occasion, marking, as it does, the commencement of a new presidential era, when we speed the parting and welcome the coming President.

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The meeting of November, 1907, will long be remembered by all who took part in it. Not only was there a large attendance in the fine lecture hall of the Institution of Civil Engineers, but the proceedings were carried through in a manner reflecting the utmost credit upon everyone concerned.

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It is not too much to say that all those present went away with that indescribable sense of satisfaction which an engineer always feels when he sees good work well done.

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Both Mr. Bryan and M. Canet must have been impressed by the large number of new members and associates announced as having recently joined our ranks. This is surely one of the most significant indications of the usefulness and reputation of our Institution.

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A hearty welcome was spontaneously given to the three gentlemen from the French Embassy who attended in support of their distinguished countryman. We were thus able to demonstrate that, in offering M. Canet the highest honour at our disposal, we not only recognise the value of his life work, but also the inventive genius and technical skill of our French engineering *confréres*, who, as Mr. R. H. Parsons aptly remarked, have shown the world how to fly in the air (dirigible balloons), speed over the land (automobiles), and dive under water (submarine vessels).

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In speeding the retiring President the members showed their warm appreciation of his work amongst us, and for us, during his year of office. It is always a pity that, having but one presidential chair the Institution has to lose one good man from

its premiership in order to gain another. For the ex-presidential feelings on such occasions we are not able to vouch, but, probably, they are somewhat the same as are those of Cabinet Ministers (we cannot vouch for these either, by the way) and that the pleasure of accepting office is only equalled by the delight experienced in being relieved of it.

* * * * * *

To our new President a cordial welcome was given when introduced by Mr. Bryan. Having been presented with the Institution officer's badge and certificate of his election—in a tri-coloured case—M. Canet commenced to read his inaugural address, and as he proceeded it became more and more evident that we had every reason to congratulate ourselves upon our good fortune in adding his name to the Institution's roll of distinguished engineers of whom we are so justly proud.

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Not only was the whole address read in our tongue—in itself no mean accomplishment—but the comprehensive survey and interesting comparisons upon the artillery used in the armies and navies of France and England to-day, were so plainly expressed and tactfully referred to, that M. Canet himself made the meeting a memorable one.

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His audience showed their pleasure in the usual way at unusual length, and it is to be hoped that the hearty and prolonged applause was accepted by the President as a token of recognition of the value of the Address, and that, in some measure, it repaid him for the great amount of work which must have been involved in the preparation of his important treatise, which will be re-read by the whole of the civilised world.

* * * * * *

During the evening an opportunity occurred of expressing the gratification felt in seeing our President of 1885, Sir Alexander Kennedy, at the Council table. No fewer than five of our past-chairmen were also present. If this paragraph should meet their eyes—as no doubt it will—we trust that they will take it as an expression of thanks and a cordial invitation to maintain their attendance.

Mr. Adam Hunter's reception was in the nature of a welcome quite as much as an indication of the pleasure generally felt that the Institution Silver Medal of the previous session had been awarded him.

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It was suggested in the Council's last report (page 31 *ante*) that the excellent example initiated by our Coventry members, under the leadership of Mr. H. H. Thorne, of holding informal meetings for the consideration of the communications presented to the Institution in London, might well be followed in other directions, and result eventually in the establishment of local sections as provided for when the Institution became incorporated in 1905.

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We feel considerable pleasure therefore in publishing this month, with the report of the Coventry meeting, that relating to a similar gathering of Birmingham members and friends, the inception of which is due to Mr. R. B. A. Ellis, who, until his removal to the provinces, was one of our most active London men.

* * * * * *

The sympathy of the members who made the visit to the Blackfriars Bridge Widening Works, reported in our present issue, will be felt for the relatives of the four workmen who lost their lives, and for Sir William Arrol and Company, in the accident which recently occurred during the lowering of the caisson we saw being got ready on the staging.

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The Institution of Automobile Engineers is to have a paper on 11th December by Mr. Dugald Clerk on "The Principles of Carburetting as determined by Exhaust Gas Analysis," and one on the 8th January by Dr. H. S. Hele-Shaw on "The Fuel Question."

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Attention should be directed to the "Special Notice" in our announcements this month intimating that the December meeting will be held at the Society of Arts instead of the Westminster Palace Hotel, as previously announced.

BASIL PYM ELLIS.

R. W. NEWMAN writes from Grahamstown, S.A.—By the sudden death of Mr. Basil P. Ellis (Honorary Member), on 5th October, 1907, the Institution has lost one who was chiefly known to the members as a partner in the firm of John Aird and Co., and who had taken an active part in the construction of the Assuan Dam, but to enumerate all the undertakings with which he had been connected would be to place on record all the great works which his firm has constructed during the last thirty years.

As a member who had the privilege of serving under him for eleven years, may I be allowed to add a tribute of appreciation to an honoured and respected name?

Mr. Ellis was a man of imposing build, with massive head and bushy beard, whom one could not fail to respect at first sight; his somewhat loud but pleasant and always cheerful voice one could never forget. His untiring energy, his extraordinary grasp of detail, and his absolute confidence in those whom he placed in positions of trust gave strength to those under him. Below his stern but kindly manner lay a heart which beat with a real sense of justice; he was a chief for whom to work was an honour. Well do I remember my parting with him and his firm in 1903.

Mr. Ellis took a deep interest in all that concerned junior engineers. Though not elected an Honorary Member until November, 1906, the work of the Institution was not a closed book to him; often had he spoken in kindly terms to me about it.

We have lost in him a true friend, and one whose name added honour to our roll. The heartfelt sympathy of the members will go out to his widow and family, and the partners of his firm in the loss they have sustained.

NOTES AND QUERIES.

10.—RUNNING OF LARGE INDUCTION MOTORS.

S. C. JAGER, of Manchester, writes:—I should be much obliged if any member who has had the handling of large induction motors of from 150 H.P. upwards, could inform me, through the medium of *The Journal*, whether he has experienced any trouble due to the rotors fouling the stators, when the bearings have become slightly worn. To obtain a low iron loss, and consequently a maximum efficiency, air gaps are made extremely

small, and a slight decentralisation of the rotor causes very heavy magnetic pulls at the point of minimum air gap. When these machines come on test, I often have considerable trouble in consequence of this; the slightest slack in the bearings resulting in a "pull over." Observing this has made me wonder whether users of this particular type of motor experience much trouble from the same cause, and if so, how they overcome it.

SOUTH AFRICAN RAILWAYS, &c.

ALFRED TINGLE (Member) having made a somewhat extensive tour in South Africa, has sent the following notes of his impressions:—Arrived at Cape Town, the writer's experiences commenced with a journey by rail, lasting the greater part of a week, to Bulawayo. Its situation was determined upon largely through sentiment—it stands on the site of Lobengula's headquarters—and partly in hopes of the development of a gold mining industry that was to rival the Rand in output; but the position of Bulawayo to-day is unenviable, as owing to its distance by rail from all the large centres of population, the railway rates eat up all profit on its agricultural produce, and the reef having proved to be patchy, no large gold mining company can work it and depend on earning an adequate return. The most profitable method of obtaining the gold is carried on by private individuals, owning, say, a 5-stamp battery with the other necessary plant, which is moved from place to place as the patches of reef give out.

The first thing that strikes the railway traveller in South Africa, knowing beforehand that the gauge is only 3 feet 6 inches, is the enormous size of the rolling stock, trucks with a capacity of thirty tons being the rule rather than the exception, and corridor trains with dining cars universal for long journeys. As to the track itself, the writer is not a railway man, but at first glance the setting out of the line certainly does appear to be distinctly casual. As an old driver on the Rhodesia Railway put it: "Yes, these chaps that lay out the line give you about three quarters of a mile of 1 in 40, and when you think you've reached the top, they twist you round a 3 chain curve and give you 200 yards of 1 in 30 to top off with." Although, perhaps, there is some exaggeration in this, the contour of the line more nearly resembles that of an English country road than that of an English railway. Single

track is universal, and in the rainy season "wash outs" are frequent; one train, during construction, on the Bulawayo-Victoria Falls section, put up a record of some seventeen derailments in the course of two miles.

After visiting the Victoria Falls the writer proceeded by way of Kimberley (where he paid a most interesting but hurried visit to the splendidly equipped De Beers mines) to Port Elizabeth. The general depression and badness of trade common to all the British South African coast towns was here particularly marked. The towns in question attribute this want of business largely to the fact that the Transvaal imports more and more through Beira and Delagoa Bay, thereby effecting a saving on railway rates, but at the same time diverting much shipping from Cape Colony and Natal.

After a short stay in Port Elizabeth, the writer went on to Johannesburg. Although still suffering very severely from the effects of the war, the outlook here was certainly brighter than in any other part of British South Africa. When the much discussed labour question is settled, the Rand should go ahead and regain its former prosperity. As to the prevailing "Chinese" question, the great ignorance which was displayed on the subject by politicians of all parties during the General Election cannot be realised unless one has studied the question on the spot.

From the engineer's view, Johannesburg, or rather the Reef, is the most interesting part of the South African Colonies; the mines being equipped with magnificent machinery of great power, and very complete repair shops; electric lighting is universal. Motor cars are extensively used, and there is every prospect of an increasing demand for them, but as roads, as we know them, are non-existent, makers of cars for this market should pay special attention to giving as much clearance as possible between the car frame and the ground, and to the strengthening of frames, back and front axles, and wheels. Many cars delivered in Johannesburg have had to have their axles strengthened as a preliminary to use.

With regard to prospects for engineers at present, the writer would like to seriously caution his fellow members that South Africa is now overstocked with both men and material; and he earnestly advises no member to think of going there for some time to come unless, of course, an appointment is secured before leaving home.

WELCOME TO M. CANET.

The Second Ordinary Meeting of the Twenty-seventh Session was held at the Institution of Civil Engineers, Great George Street, Westminster, on Monday evening, 18th November, 1907, the attendance being 280.

The chair was taken at 8 p.m. by the retiring President, Mr. William B. Bryan, M.Inst.C.E.

The minutes of the meeting held on the 18th October last were read, confirmed, and signed.

Mr. Bryan announced the receipt of a letter from His Excellency the French Ambassador, M. Paul Cambon, expressing his regret at being prevented from attending the meeting, and stating that he had deputed M. Leon Geoffray, Minister Plenipotentiary, to represent him. The Institution was also honoured by the presence of Lieut.-Colonel Huguet, Military Attaché, and M. A. de Fleurian, Secretary, from the French Embassy.

The following list of elections to the Institution since the last notification, was read:—

President.

Jean Baptiste Gustave Adolphe Canet	Paris.

Members.

Arthur Capel Valentine Baines ...	Somerset East, Cape Colony.
Charles Beaven	Hammersmith.
Anthony Frank Bentall	Chelmsford.
Charles Bentall	Peterborough, Ontario.
Leonard Bentall	Rayleigh, Essex.
Maurice Bernon	London.
Stanford Morton Brooks	Oxshott.
John William Chappell	Weymouth.
Raymond Correa...	Hendon.
Joseph Charles Costigan	Shepherd's Bush.
Samuel Cowen	London.
Harold Evans	West Dulwich.
Edward Searle Feilden	Acton.
George Frederick Glenn	Westminster.
George Ernest Handley	Worcester.
Percy Gilbert Handoll	Camberwell.
John Frederick Stanley Hards ...	Westminster.
Charles Richard Harrison ...	Singapore, Straits Settlements.

Philip Thomas Hine	... ...	Walthamstow.
Walter Thomas Hogg	... ...	Sutton, Surrey.
Myles Wesley Horsfield	... ...	Surbiton.
Sydney George Gillespie Hugget	...	Westminster.
Vivian Jobling	... ...	Mitcham.
Harold Medway Martin	... ...	Croydon.
Frederick William Moore	... ...	Manchester.
Edward William Murray	... ...	Dalston.
John A. G. Ogilvie	... ...	Stroud Green.
Edwin George Overing	... ...	Blackheath.
Howard Thomas Poole	... ...	Coventry.
Frank Edward Powell	... ...	Auckland, New Zealand.
William Edward Press	... ...	Bow.
John George Rogerson	... ...	Scotstoun, N.B.
Sriram Venkata Subba Setti	...	Chitmagalur, Mysore.
William Wallace Sinclair	... ...	Herne Hill.
Cuthbert Singleton	... ...	South Hampstead.
Stephen Charles Smith	... ...	Coventry.
Alfred Clifford Swales	... ...	Leeds.
John William Sydenham	... ...	Edinburgh.
William Thorpe	... ...	Finsbury Park.
Charles Julian Vick	... ...	Barranquilla, Republic of Colombia.
Charles Wall	... ...	East Dulwich.
Walter Henry John Wangford	...	Clapham.
Sidney Benjamin Wates	... ...	Bexley Heath.
John Weston	... ...	Brockley.
Ralph Alexander Whitson	...	Masern, Basutoland.
Arthur Rowland Wilkinson	...	Clapham Park.
William Beville Thomas Wimberley		New Southgate.
Cecil Gibson Young	... ...	Lowestoft.

Associates.

Albert Arthur Attwood	... ...	Blackwall.
Henry Charles Bird	... ...	St. John's.
Harold Gowans Ferguson	...	Crouch Hill.
Frank Joseph Hill	... ...	Kilburn.
Eric Phillippo Ernest Hudson	...	Reepham, Norfolk.
Ernest Edwin Kell	... ...	Hampstead.
George Oswald King	... ...	East Dulwich.
Harold Austin Bassett Lowke	...	Northampton.
John Robert Macdonald, Jun.	...	Brondesbury.
George Campbell Munday	...	Bromley, Kent.

Ralph Lionel Sargeant ...	...	Upper Tooting.
Norman Harry Stringfield	...	Neasden.

Transferred from Class of "Associate" to that of "Member."

Henry Haward Grey ...	...	West Hamptead.
Thomas Germann ...	...	Finsbury Park.

The President reported that a grateful acknowledgment had been received from Mrs. Ellis of the letter of condolence sent by the Institution on the occasion of the death of Mr. Basil P. Ellis, Hon. Member.

The Institution Silver Medal of the Twenty-sixth Session was presented to Mr. Adam Hunter, for his Paper on "The Structural Design of Engineering Factories."

A vote of thanks to Mr. Bryan for his services as President during the past session was proposed by Mr. L. H. Rugg (Past-Chairman), seconded by Mr. Geo. T. Bullock (Vice-Chairman), and carried by acclamation.

Mr. Bryan having responded, then inducted to the chair his successor, M. Gustave Canet (Past-President of the Institution of Civil Engineers of France), investing him with the Badge of an Officer of the Institution, and handing him Certificate of his election as President.

M. Canet delivered his Presidential Address on the subject of "Some Comparisons between French and English Artillery."

At its conclusion, moved by Mr. Frank R. Durham (Chairman), seconded by Mr. R. H. Parsons (Member of Council), and supported by Mr. R. A. Hadfield, it was resolved by acclamation that a vote of thanks be passed to the President for his Address.

M. Canet having responded, on the motion of Mr. Percival Marshall (Past-Chairman), seconded by Mr. W. J. Tennant (Past-Chairman), a vote of thanks was accorded to the Council of the Institution of Civil Engineers for their kindness in granting the use of their rooms for the meeting of the Junior Institution of Engineers.

The proceedings closed with the announcements of the ensuing visit on Saturday morning, 23rd November, at 10 a.m., to the Royal Arsenal, Woolwich, and the ensuing meeting on Tuesday, 10th December, when a Paper on "Arc Lighting" would be read by Mr. William Krause.

VOTES OF THANKS.

Before Mr. Bryan vacated the Chair

MR. LEWIS H. RUGG (Past-Chairman), proposed a vote of thanks to the Retiring President, and said it appeared to him that the resolution called for a deeper sense of obligation each year. During the past session Mr. Bryan had more than filled his office, for, not content with the customary duties, he had made handsome donations, both to the General and Benevolent Funds, and had attended some of the ordinary visits and meetings. Mr. Rugg was anxious that members should reflect on what it was they had to thank their Presidents for, and what it was they, as an Institution, gave in return to them. In regard to the first point, he reminded them that it was not only for the Presidential Address, important as that was, nor yet only for their presence at the usual functions of the year, but was quite as much, if not more, for the man himself, by which he meant his attainments and position in the engineering world, which high qualifications cast their reflection on the Institution, and consequently did credit and honour to themselves. Touching on what the Institution gave in return, Mr. Rugg pointed out that not only were the names of the Past-Presidents enrolled on a list which he ventured to think was second to none, but the members always cherished feelings of gratitude and affection for their Past-Presidents, who time and again showed the continued and unabated interest which they took in the progress and welfare of the Institution.

MR. GEO. T. BULLOCK (Vice-Chairman) said the privilege and pleasure had devolved upon him of seconding the resolution proposed by Mr. Rugg. It was certainly a privilege to be associated with this expression of appreciation of the invaluable services which Mr. Bryan had rendered the Institution as President during the past year; an appreciation undoubtedly felt by every member. It was a pleasure because Mr. Bryan had so worthily upheld the traditions of the presidential chair. His qualifications as an engineer were well known, but the members had become acquainted with his qualifications as a President. Always accessible whenever the Council sought his advice, he had assisted the progress of the Institution in many ways, a characteristic common to all his predecessors, and on

which the Institution might justly pride itself. He hoped Mr. Bryan would not think that having served as President he was to be put on the shelf, for that was not the Institution's intention or custom, as many of the Past-Presidents, who were always ready to help in every possible way, could testify. He called on the members to heartily support the resolution now before them.

MR. WILLIAM B. BRYAN, in acknowledging the resolution, after thanking the proposer and seconder for the kind words they had used in presenting it, referred to the pleasure he had felt in occupying the position of President, and regretted that the demands upon his time had prevented him from doing more for the Institution than his record had shown. He had been very glad to arrange for the various visits to works under construction for the Metropolitan Water Board and to pumping stations, &c., and in the future would be happy to assist in the arrangement of other visits. He wished the Institution continued success as he was sure it would enjoy under the presidency of the distinguished engineer who was now to succeed him. He had the honour of asking M. Canet's acceptance of the badge of an officer of the Institution, and the certificate of his election as President, and of inducting him to the Chair.

M. CANET then delivered his Inaugural Address (see page 111) on "Some Comparisons between French and English Artillery."

At the conclusion of the Address

MR. FRANK R. DURHAM (Chairman of the Institution), said he felt he had the sympathy of all the members in rising as he did to propose that a hearty vôte of thanks be accorded the President M. Canet for his address to them that evening. It might have occurred to some that the Institution, British as it was, had taken a rather unusual step in going beyond the bounds of the United Kingdom for its President, but he was sure that after the extremely comprehensive and interesting address that had just been delivered, those who were in doubt would appreciate and acknowledge the wisdom of the Council's action.

The Institution had ever endeavoured to secure as its President one of the leading authorities in a special branch of engineering science, and therefore had the courage to ask M. Canet, who held such a prominent position in that branch of the engineering profession relating to the design of modern ordnance with which

his name would ever be so intimately associated throughout the world. Besides, M. Canet was no stranger to the Institution, having been for a number of years an Honorary Member, and latterly a Vice-President. He had delivered his address, spoken in the English language, in that decisive manner so characteristic of him. The members were justly proud of these annual presidential addresses. They were becoming a most interesting and important collection of records of the progress of engineering science and a compendium of advice to the young engineer whom the Institution, as a body, represented. He believed he would not be saying too much when he added that this present address would stand conspicuous in the Transactions.

The Council went abroad with the firm conviction that science recognises no frontiers; that it is through science that the great progress of the world is being accomplished, and that it may be through science that the Utopia of universal peace would be attained. The engineer was probably the greatest peace-maker in the world, for it was he who was responsible, in the first place, for the spread of civilisation by his works of utility; it was he who, as the designer and the constructor of all engines of war, demonstrated to his fellow creatures how dangerous and expensive it was to play with firearms, and thus by his ingenuity to persuade them to a peaceful life.

MR. DURHAM concluded as follows:—Monsieur le Président, C'est avec les sentiments les plus sincères que je vous prie d'accepter les remercîments chaleureuse de notre Institution. Nous vous remercions d'avoir bien voulu consentir à devenir notre President et du discours éloquent et intéressant que nous venons d'entendre. Nos applaudissements vous auront appris combien nous en avons joui et combien vous êtes le bienvenu La Science est le lieu le plus sûr entre les nations et nous osons compter votre présence parmi nous comme un anneau de plus dans la chaîne de l'amitié entre nos deux grands nations. Monsieur le Président, merci!!

MR. R. H. PARSONS, in seconding the vote of thanks, said there was one point in connection with the development of modern artillery to which M. Canet had naturally made no reference. It was entirely non-controversial, and in spite of, or rather because of the fact that it had not been mentioned in the address,

he trusted he might be allowed to refer to it. He alluded to the great share that M. Canet had himself taken in bringing about the improvements in artillery of which they had heard that evening.

During the last thirty years the gun had developed from an erratic and none too reliable piece of apparatus into a machine of extraordinary precision. A reference to the discussion before the Institution of Civil Engineers mentioned by M. Canet would show how greatly ideas had changed and knowledge had increased since then, and it was largely to M. Canet and his fellow workers that this great advancement was due. The speaker believed he was right in saying that M. Canet practically founded the private gun-making industry in France. In the face of enormous difficulties and in spite of every discouragement, he started the manufacture of ordnance in that country. He had to train his own draughtsmen and mechanics, who had none of them ever seen a gun, but the long and uphill task bore good fruit, and the French field gun, which, by the way, had been adopted by almost every nation not making its own ordnance, and had been copied by most of the others, was largely the result of his efforts. For many years he had been director of ordnance at Messrs. Schneider's Creusot and Havre works, and the Schneider-Canet guns were world-famed and had, as was generally known, recently beaten those of several other makers, including British, in open competition.

M. Canet had said some very nice things not only about English engineering, but about British Government policy. It was indeed gratifying to see ourselves as others see us, but it was to be sincerely hoped that his flattering words would not make our War Office or the Government generally, too proud of itself. In thanking him for his address, Mr. Parsons felt the members of the Institution should record their high appreciation as engineers of the work of their *confrères* across the Channel. The French were as courageous in peace as in war, and their engineers had set many an example to the world in the arts of both. New ideas seemed to flourish better on French soil than elsewhere, and men were to be found there with confidence enough to push them to a successful issue. The Suez Canal was an everlasting monument to French engineering genius. To the same nation were due ferro-concrete, artesian wells, and

other engineering things of everyday use. They had taught how to go about in the heavens above, the earth beneath, and waters that were under the earth, by the use respectively of balloons, motors cars and submarine boats. They had devised even more effective ways of killing people with smokeless powder and machine guns, and the various refinements of which the President had spoken in his address.

Whether guns would ever become either so perfect or so costly as to prohibit war, as was sometimes suggested, was very unlikely. Probably the same idea was held in the days when the Roman trireme was quite the latest thing in battleships, and yet with the modern Dreadnoughts finality seemed to be as far off as ever. The only thing to be done was to be prepared for war, but not willing to fight except when the alternative was worse than war.

The presence of M. Canet as President of the Institution was one of the happy results of that *entente cordiale* which practically assured the peace of Europe, and he knew the members would wish to show their acceptance, in the heartiest manner possible of the vote of thanks which had been proposed. He had very much pleasure in seconding the resolution.

MR. R. A. HADFIELD, who was asked to support the resolution, said he had much pleasure in doing so, and that whilst he had listened with great interest to M. Canet's valuable address, he thought, in view of its importance when dealing with the question of advances in artillery, that some reference might be made to the great improvements in the manufacture of armour piercing projectiles, particularly in regard to those fitted with caps. It was now possible to perforate one-calibre Krupp cemented plates, the projectiles emerging practically unbroken under this severe test. In a recent proof at Shoeburyness, a 12 inch "Heclon" capped projectile made by his firm perforated unbroken a 12 inch K.C. plate, the projectile being recovered some distance in the rear in a condition for bursting. This projectile if fired uncapped and at the same velocity, would have been broken into thousands of fragments, moreover, penetration would not have been more than about 3 inches or 4 inches. Mr. Hadfield, in complimenting M. Canet's firm, Messrs. Schneider and Co., Le Creusot, also referred to the great loss which it had sustained through the sad accident in which M. Geny lost his life. In conclusion, he con-

gratulated M. Canet upon his excellent address, and thought the Institution very fortunate in securing him as President.

THE PRESIDENT, in acknowledging the resolution, said he thanked the members most heartily for the very kind way in which his address had been received. He had been much touched by the kind remarks made by the proposer and seconder of the vote of thanks, and by his friend Mr. Hadfield, the well-known maker of cast steel shells. He was also greatly obliged to Mr. Bryan for what he had said, and felt that he did not deserve so many compliments. The warmth of the reception which the Institution had extended was deeply gratifying to him. When he was asked to undertake the duties of President, he felt at first some reluctance to accept the offer. His reasons were two-fold. In the first place there was the fact of his French nationality, and all that it implied with regard to difficulties of language and distance. Then again, his life's work had been confined to a very specialised branch of engineering—the manufacture of ordnance—a subject which he feared would have a direct interest for very few of the members. Practically every other form of engineering work was directed to the immediate and obvious welfare of mankind. His predecessor in this chair, Mr. Bryan, for example, had devoted himself to providing the inhabitants of the great city of London with one of the primary needs of existence. Gunmakers, however, directed all their energies to the perfection of means of destruction, so that perhaps on the whole it was better that their work did not appeal more widely to the engineer.

The reasons that he had given for hesitating to accept the Presidency of the Institution were over-ruled by other considerations, which on reflection he did not think it right to disregard. He felt it his duty as a Frenchman, as he held it to be the duty of those whom he addressed as Englishmen, to assist in strengthening the *entente cordiale* which now so happily existed between the two nations. Mutual intercourse brought mutual understanding, and everyone was bound to do all in his power to strengthen and consolidate that great edifice under which lay buried, he trusted for ever, the senseless quarrels of a thousand years.

Then again, he was glad of the occasion to acknowledge how much he owed to the English, and especially to that eminent

engineer Mr. Vavasseur, of Elswick, under whom he received his early training. Ever since those days, when he first came into contact with English engineers, he had admired the excellence of their work and the rapidity and energy with which it was carried out. The simple and straightforward business methods of the English were also examples to his countrymen across the Channel, for in France he feared "red-tape" was much prevalent, and transactions could not therefore be completed so quickly and easily as was customary in England.

Perhaps, however, what influenced him most was the fact that the Institution existed for the benefit of the Junior members of the profession. He maintained that it was the duty of the older engineers who had attained some measure of success in life to stretch out a helping hand to the younger men and assist them up the ladder. It should be remembered that the young men would in time replace the older, and all that could be done to help them on would be for the ultimate good of the whole profession and of mankind at large. Their progress should please their seniors, and if the juniors departed from established usages their methods should not be condemned merely because they were new. Older men did differently to their fathers, and should look to their sons to improve upon their work.

His advice to young men was that they should study the work of their elders, treat their opinions with deference, respect their experience, and profit by it to the utmost. But they should never forget that science was progressive. The advance of knowledge might point to the necessity of leaving the beaten track and of adopting new ways and other methods. In such a case the new way should be tried, and if found to be a better one should be freely adopted, and the old teachings abandoned without regret. Once more he thanked them.

MR. P. MARSHALL (Past-Chairman) proposed, MR. W. J. TENNANT (Past-Chairman) seconded, and it was resolved by acclamation, that a cordial vote of thanks be passed to the Council of the Institution of Civil Engineers for their kindness in granting the use of their rooms for this meeting of the Junior Institution of Engineers.

INAUGURAL ADDRESS
ON
"SOME COMPARISONS BETWEEN FRENCH AND ENGLISH ARTILLERY,"

By THE PRESIDENT, M. GUSTAVE CANET
(Past President of the Institution of Civil Engineers of France).

Delivered 18th November, 1907, at the Institution of Civil Engineers, Westminster.

M. LE MINISTRE, MR. BRYAN AND GENTLEMEN :—

I wish to thank the members of this Institution most heartily for the honour they have done me in electing me their President for the forthcoming session.

I little thought, a quarter of a century ago, when making what was practically my maiden speech within these very walls, that I should ever be addressing your Institution from this famous chair. I was then a young man almost fresh from the Engineering College, standing in the presence of his seniors, and speaking here to-night under such changed conditions revives memories which touch me deeply.

On the occasion to which I have referred, I took part in a discussion on the manufacture of ordnance, and it is with the same topic that my address this evening will deal. It may seem strange to talk of guns on the morrow of the Hague Conference, and while the *entente cordiale* makes the prospect of a European war so remote. The old Latin adage, however, "*Si vis pacem para bellum*" is as true to-day as when it was uttered for the first time, and until human nature itself changes, the art of the gunmaker will unfortunately be necessary to the security of nations.

The amount of money and skill expended annually by the great nations on the production of war materiel is something enormous. Type after type of armament is devised and becomes obsolete without ever having been used in actual warfare. The money spent on equipment for war that never comes is, however, by no means entirely wasted. It is so vital to a nation to possess the best possible guns and armour that the desire for improvement

stimulates invention and hastens progress in all the mechanical, metallurgical and chemical arts. Military necessity develops knowledge that can be turned to account in many directions for the welfare of mankind, so that in this respect also the arts of war serve the cause of peace.

I propose in my address, and I hope it will not be uninteresting, to consider a few of the points of difference between English and French practice in connection with the design and manufacture of artillery. First, however, it is necessary to point out the difference in the conditions under which gunmakers work in the two countries, for this has an important bearing on the question.

In England, with that liberal common-sense so characteristic of the nation, there has never been any restriction placed upon manufacturers with regard to the supply, during peace time, of war materiel to foreign Powers. Hence, largely for this reason, works such as those of Messrs. Armstrong and Vickers, have developed which not only employ profitably a great number of workmen, but can place all their resources at the disposal of the Government in case of need. Furthermore, the vast experience of such firms is a valuable national asset, and the emulation between them and the Government arsenals tends to improve and cheapen the fighting materiel of the country. By refusing to supply weapons to other nations, a country not only renounces a remunerative source of trade, and loses experience that might have been gained, but encourages possible enemies to develop arsenals of their own. It is a short-sighted policy regarded from any point of view, and England is to be congratulated on having seen the wisdom of encouraging the manufacture of war materiel, and of keeping the private works in a high state of efficiency by placing with them a large part of the national orders.

In France, on the other hand, there has unfortunately been a feeling that the manufacture of war materiel should be a monopoly of the State. Moreover, until the law of 25th August, 1885, there were very heavy, if not prohibitive, restrictions placed upon the supply of weapons to foreign nations, so that the development of private firms was almost impossible. Of late years, matters have improved somewhat, although even now the liberty of French manufacturers is far from complete. The manufacture of all powders and explosives, excepting dynamite for mining purposes, is still retained as a monopoly of the Government, from

whom ammunition makers must purchase all that they use. Besides this, private works are under the constant surveillance of resident officers, who take note every day of all that passes in the shops and proving grounds. Until a few years ago, particulars of every new design and results of every experiment had to be submitted to them, and in fact, even now, firms can keep for themselves no new discovery or process of manufacture, at whatever cost it may have been obtained.

It will be seen, therefore, that the whole tendency of French policy has been adverse to the interests of private manufacturers, and also, I am convinced, to the best interests of the nation. State orders are given almost exclusively to the Government factories, and no work is placed in the hands of private firms except what the arsenals find it beyond their capability to accomplish. I may mention as an instance, that the War Office, since 1873, has only ordered from French makers fifteen guns above 2 inch calibre. The naval authorities, who constitute an entirely separate department of the State have, however, been somewhat more generous, and there are now signs of a more liberal policy for the future. It may therefore be hoped that the French Government will in time realise the national importance of the existence of private factories of war materiel, and will encourage them by apportioning to them a judicious share of orders as is done in England.

With this ungenerous treatment by the Government, it is easy to understand what tremendous exertions must have been made by private French firms to develop an industry which will compare with that of England.

I now turn to the points which distinguish French and English official materiel now in service and with which I propose to deal more particularly to-night. There are in this connection certain matters which every nation naturally desires to keep secret, and into these it would not be right for me to enter.

GUNS.

Principles of Construction.—The question of the construction of guns is obviously of fundamental importance, and here we find a marked divergency of practice. To take a specific instance, we will compare the latest types of large naval guns of the two countries. The English 12 inch gun (mark IX.) is of 40 calibres

length of bore, and consists of a steel tube, wound practically from end to end with numerous layers of steel ribbon or "wire" of very high tensile strength. This tube, called the "A" tube, is shouldered down to successively smaller diameters and thicknesses from the breech to the muzzle, and each successive layer of wire is wound on at a decreasing tension. Altogether, over 100 miles of wire are employed. The wire along the chase or fore-part of the gun is covered by the "B" tube, which is shrunk over it. Over the rear portion of the winding and part of the "B" tube is shrunk the breech jacket into which a bush is screwed, preventing movement of the "A" tube relative to the jacket. Inside the "A" tube is a thin steel inner tube inserted from the breech and held in position by a breech bush. This inner tube can be renewed when cracked, corroded, or otherwise damaged by use.

The corresponding gun in the French Navy is 305 millimetres (12·008 inch) bore and 45 calibres length of bore. In the foundation tube are formed both the chamber and the bore of the gun, as there is no liner employed. This tube is strengthened by a number of steel hoops shrunk round it, two layers with "broken joints" being used for the rear part where the pressure of the explosion is greatest, and over these again is shrunk a very thick jacket. Around the chase the hoops are much broader and heavier. The breech mechanism, as in the English gun, is screwed into a breech bush.

It will be seen that the practice of the two countries differs radically upon two points, firstly, the use of wire winding, and secondly, the employment of a thin renewable liner. Other details are of minor importance. Now, I am not going to say that one system is better than the other, because a Presidential address should be non-controversial, and the question is one upon which no agreement seems possible. Instead of doing so, and now that I have called attention to the difference in the ideas of the naval authorities of the two countries, as embodied in the types of guns they prefer, I may perhaps put before you certain conclusions that I myself have come to on the subject of gun construction generally.

In the first place, there is the question of wire winding. It was on this subject that I spoke in the discussion to which I have referred, when I expressed my belief in the efficacy of the

principle. I was then a young man and possessed that reverence for formulæ and mathematical science that all good young men should have. There can be no doubt that if the assumptions of the mathematicians are correct, a wire wound gun is the strongest construction that can be made, at any rate so far as resistance to bursting pressure is concerned. But an experience of more than thirty years has shown me that the conditions are very different from those assumed in the mathematical treatment of the subject. Nevertheless, if gun steel had remained of the same non-homogeneous and unreliable quality as it was when the wire gun was introduced, I should have remained in favour of the principle of wire winding, which has been brought to perfection by English engineers. Enormous advances have, however, been made, and metallurgists can now provide us with steel in large homogeneous pieces free from defects and of such splendid quality, high elastic limit and breaking strain, with great elongation that I am convinced that wire winding is not necessary. Into questions of longitudinal strength and rigidity of the chase I will not enter. As regards weight, neither gun has any advantage over the other.

Having said this you will no doubt expect me to give you my own conclusions as to how guns might be most efficiently and simply made with the steel now at our disposal. Before doing so, I will ask you to consider what takes place in the bore when a gun is fired. The rapidly vibrating molecules of the incandescent gases are hammering the wall and the breech piece, and produce pressures tending to burst the gun longitudinally and transversely, while the action of the rifling in giving rotation to the projectile produces a certain amount of torsional stress. Besides this, the heating of the interior of the bore causes enormous stresses due to unequal expansion. Now, before any metal can break it must be stretched beyond its limit of elasticity, and this operation takes time. If the force ceases to act before the molecules of the material have had time to move beyond the range of cohesion, fracture will not occur, even though the force may have been momentarily far in excess of what the metal could have borne as a continuous pressure. The duration of the pressure in a gun is so short that the explosion may be looked upon as something in the nature of a blow upon the interior and given a sufficient mass of metal to withstand this, there is no time for the tube to stretch to the point of fracture before the strain

is relieved. What is required, therefore, is mass and inertia to withstand the explosion, and it follows that a thin liner inside the gun is not only useless as far as strength is concerned, but is extremely liable to be broken. It is, in fact, in the position of a thin plate placed under a steam hammer with the idea of protecting the anvil. The latter can take care of itself without a plate which, besides affording no protection, will not stand many blows without becoming fractured. The liner in a gun is certainly supported by the surrounding "A" tube as well as good workmanship can ensure, but there is necessarily molecular discontinuity, and the exterior metal acts as an anvil to reflect the blow rather than as a part of a homogeneous structure to absorb it. On these two points, had time permitted, I might dwell longer, but it is needless, as I think they are self-evident. Moreover, years ago, a most learned officer, Sir Andrew Noble, whose patient, practical and remarkable researches on artillery and explosives are world famed, pointed out that owing to the almost infinitesimal time the highest pressures acted, many guns withstood pressures that would undoubtedly cause their failure were such pressures of longer duration.

We have yet to consider the effect of the heat caused by the explosion. However good the workmanship, the interspaces between the tubes are enormous relatively to molecular distances in solid metal, and this prevents the heat from passing rapidly through the walls of the gun. There is certainly an abrupt temperature drop from one tube to the next. Hence unequal expansion takes place, and relative motion of the tubes tends to occur. If this is prevented as in the type of gun under consideration, the liner will become distorted and will be liable to crack, if not spontaneously, at any rate when the gun is fired. There is the additional danger of the premature explosion of shells in the gun, a danger by no means imaginary if a shell strikes the contracted or cracked bore. I see no explanation of the numerous failures of inner tubes which have been reported, except those to which I have drawn your attention.

I have, myself, noted the effect of unequal expansion due to heat in a few experimental quick firing guns made of a single thick tube with a long breech jacket shrunk over it. The jacket had an internal collar at the rear to prevent backward movement

of the tube, and the shrinkage fit was as perfect in every case as it could be made. After each series of rounds it was found that the tube had crept *forward* relatively to the jacket, in spite of the great frictional resistance. The breech mechanism being held by the tube, every explosion naturally tended to drive the tube *backwards*, but the heat acting unequally on the tube and the jacket, the tube expanded more, and on cooling, the contraction of the tube made it leave the internal collar of the jacket.

My view is that, having regard to the reliability of modern heavy forgings and the high quality and trustworthiness of gun steel, the guns should be built up of as few separate pieces as possible. The inner tube should be as thick and heavy as reasonable, with a rear jacket having a cross-sectional area not greatly different from that of the tube at any point, shrunk and hooked on to it. A very thin chase jacket would serve as a protection against small projectiles or fragments of shells. Inner tubes should be used only for the repair of guns when the bore is worn out by erosion in order not to lose valuable weapons that could be employed as spare guns in case of need.

To illustrate the strength of guns built on the principle I have indicated I will mention my experience with an experimental 12 centimetre (4·7 inch) quick firing gun built at Havre. On one occasion the cartridge case of a capacity of 646 cubic inches was by mistake loaded with field gunpowder. The force of the explosion was so great that the breech block threads were completely sheared off and the breech block was blown out. What the force of the explosion was, will never be known, as the steel plunger of the crusher gauge was driven clean through the copper cylinder, by the compression of which the explosion pressure is measured, the copper being formed into a ring. Notwithstanding that enormous pressure the body of the gun was uninjured, a new breech block was put in, and the gun is still serviceable and does not show any signs of weakness.

I must apologise for having dwelt so long on the question of gun designing, but I trust that the importance of the subject will serve as my excuse.

Breech Mechanism.—The introduction of slow-burning powder has very much diminished the difficulty of making satisfactory breech mechanism, and with the accurate machinery and excellent steel now at the disposal of manufacturers, this important part

of the gun no longer gives any trouble. There is, in fact, little to choose between the various types used for any particular kind of gun, but I will point out some of the distinguishing features of English and French practice.

In large guns for the French Navy the breech block is made on the principle of the interrupted screw, four portions of the thread being cut away so that an eighth of a turn will lock the breech. The English use the Welin screw, which has segments of thread of different diameters so arranged that with a very small angle of rotation, engagement can be effected around a large part of the circumference. The Welin block has a greater effective bearing of thread than the other, and thus is stronger for the same length. It is, however, considerably more difficult and expensive to manufacture, and the simple type fulfils all requirements. For some patterns of guns both the Welin breech and the interrupted screw are made of conical or ogival form, so as that when the threads are disengaged the blocks may swing out of the breech without having to move axially. The breeches of heavy English naval guns are opened and closed by hydraulic power, although alternative means of hand operation are always provided. French practice is to use manual power only, as the work is not heavy, and it gives the man something to do.

Except for the form of screw adopted, English and French breech mechanisms differ only in minor details, of which the only one of importance is the method of obturation. The English have adopted the de Bange pad obturator for all classes of guns, except of course those of the quick firing type, in which the metallic cartridge case fulfils the functions of an obturator.

The de Bange pad consists essentially of a thick asbestos washer protected by metallic discs and held against the breech block by a mushroom-shaped piece of steel, of which the stem passes through the block. The explosion of the charge compresses the pad between the mushroom head and the breech block, and forces it so tightly against the inner surface of the bore that no gas can escape past it. The arrangement is thoroughly effective, and will act even should the asbestos ring become considerably damaged. It is used exclusively in the French Army, but the naval guns are instead fitted with the Broadwell ring obturator. Should there be any grit or dirt on the rear face of

this obturator the copper ring is liable to let gases escape, and if failure occurs the consequences are very serious. This type of obturator, moreover, causes a greater pressure on the breech block and slightly weakens the rear of the gun. From all points of view pad obturation appears to me to be preferable to the other method, and I do not know of any reason, except a spirit of undue conservatism, which has prevented its adoption by the French Navy.

TURRETS.

In the British Navy the heavy guns are mounted in barbettes, whereas the closed turret system is adopted by the French. The French turrets are designed with the idea of affording the narrowest possible target, and this idea is carried out even at some expense of roominess inside. They are oval in shape, and the fixed part below the turntable is contracted for the reason above stated. The smaller the turret, of course the less is the total weight of armour necessary, but limited dimensions make it very difficult for the artillerist to arrange conveniently inside all the machinery required for satisfactory working, and on the whole I think the English practice, due principally to that most able and eminent naval architect, Sir William White, of allowing the designer plenty of weight and room inside is the best. The guns and mountings of English turrets of recent type are protected by flat plates, which avoids the necessity for bending the heavy armour. The elliptical form and the proportions of the French closed turrets, have the advantage of distributing the blows of projectiles over a greater weight of armour.

It is the practice of both nations to allow the guns to recoil axially and to take up the recoil by hydraulic buffers. The English run out the guns after recoil by hydraulic pressure, while the French make use of springs which are compressed by the energy of recoil. The training and elevating mechanism are both hydraulically worked in the British Navy, whereas electricity is employed in the French. The same difference occurs with regard to the operation of ammunition hoists and many other details.

Both systems work perfectly well, and have their respective advantages and defects. The great enemy of hydraulic mechanism is frost, and moreover, the weight of the appliances and the size of the pumping machinery are serious considerations. Electricity, on the other hand, is always and every day available

on a battleship. The leads can be taken anywhere, and the apparatus is now thoroughly reliable, although short-circuiting and breakage of leads, should they occur, are much more difficult to find out than the fracture of water pipes.

Hydraulic mechanism, moreover, has approached more closely to the limit of its development than electricity, and, in the future at any rate, I expect electrical power will be generally considered to possess the balance of advantages.

The typical English practice as regards ammunition hoists is to make them in two sections, the lower to bring the ammunition from the magazine to a relay chamber, where it is taken upward again to the gun by another hoist. This system allows of more rapid firing, as there is a large supply of ammunition under the gun, besides, in case of a shell bursting in the turret, the danger to the magazine is not so great. Hence it appears better than the use of a single hoist direct from the magazine to the gun, as is the custom in French battleships. There is another point in which I think the English practice is preferable, that is the possibility of loading the gun at any elevation. The ammunition is carried up in a curved hoist from which it can be delivered at any point and pushed home by a hydraulic rammer moving with the gun. French guns can only be loaded in one position, namely, when the gun is depressed five degrees below the horizontal, so that it has to be brought to this position after every round. The projectile is pushed home without rammer by the men serving the gun, their strength being assisted by a compressed spring, and of course favoured by the depression of the gun.

Again, as to sighting, I think the English practice of providing duplicate sights, one set at each side of every gun is the best.

In both systems there is a most important feature ; the whole of the mechanism is arranged to be actuated by hand power if need be, so that should any part get out of order, or the electric or hydraulic power not be available, the guns are not disabled, as they can be immediately worked by the men, who are trained on purpose.

I have compared the turrets on ships now afloat, but I must add that the French Naval Authorities have acknowledged the advantages of the English practice, which I have pointed out.

The turrets for the ships now building will embody all the improvements I have noticed above, such as relay chambers, loading in any position and duplicate sights, so that the rate of fire may be raised to two rounds a minute. Electricity is still retained for motive power.

NAVAL CARRIAGES.

I shall not say much on the naval mountings worked by hand as they are pretty much alike in both countries ; they differ chiefly in the sighting apparatus necessary to obtain hits at all ranges and get the full benefit of the accuracy of the gun. The patterns now in use or on trial are so numerous that it would take a whole evening to examine them and point out their relative merits.

AMMUNITION.

Projectiles.—The projectiles—common shells, shrapnel armour piercing shells, high explosive shells, case shots, &c.—fired in the English and French guns are practically the same, so that there is no difference to point out under this heading. The copper driving bands now universally used on shells of all types, are due to that most clever inventor—Mr. Vavasseur, of Elswick.

Powder.—To Mons. Vieille, a French Government engineer, belongs the credit of having first succeeded, in the year 1885, in transforming gun-cotton into a reliable smokeless powder for military purposes. The Vieille powder is simply a mixture of soluble and insoluble nitro cotton, somewhat hardened by digestion with ether and alcohol. It is known as " poudre B."

The English service powder has been adopted after a long series of experiments made by the Explosives Committee, of which Sir Frederick Abel was President. This explosive consists of fifty-eight per cent. of nitroglycerine, thirty-seven per cent. of insoluble gun-cotton (trinitrocellulose) and five per cent. of vaseline. The ingredients are incorporated and gelatinised with acetone as a solvent, and the mixture is squirted through dies. It is known by the name of " cordite," owing to the cord-like form it assumes after manufacture. The cords are cut to length and the acetone evaporated. The corresponding French powder which contains no nitroglycerine is rolled into strips.

The cellulose of the gun-cotton being an organic substance must, sooner or later, become altered or decomposed, so that the

most important property of these smokeless powders must be their stability, both chemical and ballistic, under all conditions of climate, storage and use, and this for the greatest length of time. The English and French Governments keeping secret all the data referring to that most vital question, I regret to be unable to give any opinion on this particular point.

Cordite, as compared with the "poudre B," gives more regular and, weight for weight, superior ballistic results, and has also a form more convenient to make up into cartridges; but on the other hand the nitroglycerine contained in cordite freezes at a fairly high temperature (about 40 degrees F.) and, if frozen cordite is suddenly thawed, a slight amount of exudation of nitroglycerine is noticed on the surface of the cords. Before re-absorption there is always a risk of explosion from shock or heat. But the greatest drawback of any nitroglycerine powder is the serious erosion of the bores of guns it causes, even after a very few rounds. For instance, in a 15 c/m quick firing gun after firing three rounds of Italian ballistite (which contains fifty per cent. of nitroglycerine) the bore of the gun was eroded as much as 0·1 inch in diameter for a length of some inches.

As a proof of the slightness of the erosion caused by the French powder, I may say that I have known of a 75 m/m quick firing field gun that has fired 4,000 rounds, and which is nearly as good as new, its accuracy being hardly impaired. Another 10 c/m quick firing gun on board a French training ship has fired 8,500 rounds, the greatest number with practice charges, before being withdrawn from service. I think, therefore, that the English authorities have take a step in the right direction by having recently adopted a modified form of cordite having only thirty per cent. of nitroglycerine in its composition.

High Explosives.—The high explosive used by both the English and French Governments as a bursting charge for shells is essentially picric acid. In both countries the exact composition used is kept secret, but there seems to be no practical difference between the lyddite of the English Government and the melinite of the French.

Fuses.—Fuses for causing explosion of the charge in a shell are of two kinds; time fuses, which act when the shell has reached a given point of its trajectory, and percussion fuses, which explode the shell when it strikes any object. The fuses

used by the English are very different from those used by the French, but as the proper working of a fuse almost entirely depends on the extreme care taken in the minutiæ of manufacture, priming, &c., the differences of design are not of so much importance.

Detonators.—The English provision for detonating lyddite shells consists in having a long tube of asbestos paper fixed axially in the interior of the lyddite charge to contain a bag filled with picric powder (mixture of forty-three parts of ammonium picrate and fifty-seven parts of saltpetre) this is fired by a primer of black powder ignited in its turn by the detonation of a very small quantity of fulminate, when the shell strikes. The detonator for French shells is formed with a strong tube projecting into the melinite and containing a certain amount of fulminate. If the picric powder is stable, and if there is no difference in the efficiency of the two methods, the English would appear safer, as fulminate is a very objectionable material to have except in minute quantities.

Tubes.—For igniting the charges in the chambers of guns, the English use by preference vent sealing tubes, which are fired by sending a current through a platinum silver wire bridge embedded in a priming composition of gun-cotton dust and meal powder. Provided that the dry gun-cotton dust is not liable to explode spontaneously the electric tubes seem in all respects preferable to percussion tubes which contain caps of fulminate, as they are safer and ignite the charge more instantaneously.

Quick Firing Ammunition.—In quick firing ammunition the projectile, powder charge, and exploding device are all contained in a brass cartridge case. The advantages are obvious, the powder is well protected, obturators are unnecessary, and rapidity of fire is enormously increased ; besides the case prevents serious accidents from back flash, which sometimes occurs when the breech is opened. Quick firing ammunition is used by both the English and French Governments for guns up to about 6 inch bore. When adopting the 6 inch Vickers B. L. gun, which does not use fixed ammunition, the Ordnance Committee stated that the chief advantages attained by the use of a silk cloth cartridge were saving weight and magazine space, lighter charges to handle and economy. It is possible, however, to purchase these advantages too dearly.

GARRISON GUNS.

There is a marked difference in the practice of the English and French as regards garrison guns for coast defence. The mountings of these guns are made by the English of an extremely elaborate character, with the latest improvements; they have, in fact, all the refinements and complications of naval weapons, as well as others, such as disappearing carriages, peculiar to themselves. The French, on the other hand, go in for the greatest possible simplicity, believing that money is more advantageously spent in providing a great number of simple weapons worked by hand power only than in purchasing fewer of a more costly type. Further, the maintainance in good working order of the English garrison guns and mountings is much more expensive, and requires a greater amount of skill than that of the French. However, a new 24 centimetre B. L. gun has been adopted lately in France for coast defence. It is able to fire four rounds per minute, owing to the use of an automatic loading apparatus.

FIELD GUNS.

The development of the modern field gun has been due to the necessity for providing a weapon to meet the conditions of present day warfare. The equipment of armies with small bore rifles, capable of rapid and accurate fire at long range and the invention of smokeless powder, completely altered the tactics adopted in the field. Instead of the serried ranks of soldiers and the slow evolutions characteristic of battles at the beginning of the last century, open order was substituted and infantry advances were made by short rushes. Under these conditions the enemy's infantry, lying on the ground for the greater part of the time and protected by every bit of cover available, only became a mark for the artillery during the short time, when erect and unconcealed they rushed forward. Against such tactics the older types of field guns were almost powerless.

The position of the enemy's firing line being only roughly known and its mobility being very great, it became necessary in order to destroy it, or at least to paralyse its offensive power, to sweep with grape shot the whole of the zone occupied. This work to be effective, must be carried out regularly and systematically, the shells being so placed that every yard of the ground is in

turn subjected to the hail of lead. Shrapnel bursting with time-fuses, giving a long ellipse of destruction, is the type of projectile best suited for shelling the enemy's position in this manner.

Besides being capable of performing the function just indicated, modern field artillery must be equally effective with percussion shell against fixed targets such as the guns of the enemy, buildings, walls, &c. Hence we see that the essentials of a satisfactory field gun are great rapidity of fire, and calibre large enough to take shrapnel of sufficient size and power to destroy men and horses at very long range. It must also be capable of holding its own in an open artillery duel with the enemy's guns, the advantage under such circumstances being possessed by the weapon giving the flattest trajectory and the smallest angle of impact. Furthermore, the sighting mechanism must be as perfect as possible, and special means should be provided to control the systematic sweeping fire of which I have spoken above. This class of firing involves step by step alterations of range and direction, which must be made rapidly and correctly if the full effect of the deadly possibilities of the system are to be obtained.

Before entering into a discussion of the points of difference between French and English practice as regards field guns, I ought to direct your attention to the factors which explain many of the features peculiar to each nation. England is, on account of her geographical position, essentially a naval power, and has directed her greatest efforts to the improvement of armament for fighting at sea. Hence naval requirements have had a profound influence on the design of all war materiel, and naval ideas have dominated many of the weapons intended for land service. In France, on the other hand, with long frontiers to be protected, national activity has been directed more particularly to the development of materiel for the army. More attention has been paid to military requirements than in England, and French artillery, both as to materiel and tactics, is the outcome of the necessity of meeting conditions which England has not to consider so seriously. The Army is to France what the Navy is to England, and naturally each power has reached the highest perfection in the sphere in which its interests are most closely involved.

The French artillery experts after exhaustive trials of various types of field guns, at length decided to adopt that devised by

Lieut.-Col. Deport as meeting most fully the requirements of modern field service.

The French field gun is of 75 mm. (2·95 inches) calibre, and is built up of a steel tube, strengthened by a jacket and hoops shrunk over it. It is, of course, of the quick firing type, and throws a 16 lb. projectile with a muzzle velocity of 1,740 feet per second. The breech mechanism is of the eccentric screw type. The carriage on which the gun is mounted is of pressed steel, anchored to the ground by a spade fixed at the end of the trail, the spade being so designed that the re-action of the gun compresses the earth beneath it without ploughing up the ground, or causing the spade to become buried. To prevent the carriage jumping at every round, and to ensure the greatest possible steadiness, the gun is allowed a long axial recoil, being guided meanwhile by three pairs of rollers running in the grooves of a cradle which carries the trunnions. A hydraulic buffer introduced between the gun and cradle regulates the force of the recoil and prevents any movement of the carriage. A pneumatic recuperator runs out the gun automatically after every round, and the gun thus returns to exactly the original position as regards direction. Firing to the right or left is accomplished by traversing the gun and trail together along the axle, these parts rotating about the spade as a pivot. In traversing they remain always at right angles to the axle, constraining the latter to rotate slightly in order that this relationship is maintained. The required motion is given by means of worm gearing.

On level ground the carriage remains perfectly steady when firing, but to prevent the possibility of lateral movement when the axle is not horizontal, the wheel brakes are arranged so that they may be dropped down and act as scotches to the wheels. To facilitate the working of the gun and to still further increase its stability, the gunners are seated on a saddle on each side of the trail. A steel shield of sufficient strength to protect them from rifle or shrapnel bullets also aids by its weight in steadying the gun.

The gun has an independent line of sight, that is, it, together with its cradle, is mounted by trunnions on an intermediate framing attached to the carriage. This framing can be rotated about the trunnions. Thus by elevating the framing the gun may be brought to bear point blank on the target, the

necessary elevation for range being obtained by separate mechanism which moves the gun and cradle relatively to the framing. The sights are attached to the framing, and thus remain on the point aimed at whatever alterations or corrections for range may be necessary. The sighting apparatus is placed on the left hand side of the gun and consists of a quadrant, on the top of which is placed the pedestal sight. This contains a collimator, in which appear the images of two white lines crossing one another at right angles. Sighting is effected by moving the gun until the intersection of the lines coincides with the object sighted. This, in general, will be chosen for convenience by the battery commander, and will not be the same object as that aimed at, the latter being usually out of sight of the gunner. A goniometer dial, graduated in thousandths, is set at some angle to the right or left of zero, prescribed by the battery commander, so that when the sights are on the object given, the gun will be pointing in the direction required. Should the shield interfere with the use of the pedestal sight the latter can be raised on a long bar until clear of obstruction.

The service of the gun requires three men, whose duties are as follows:—The layer, who is seated on the left hand side, sets the pointer on the graduated quadrant to the angle of sight and lays the gun. There is on the quadrant a spirit level which is put horizontal when the angle of sight is correct, and the layer keeps it always so during firing. The elevating number, seated on the other side, gives elevation for range as instructed by the battery commander. These two operations are quite independent and can be accomplished simultaneously. The third man is the loader.

With the sighting attachment described, the French field gun fulfils the conditions I have mentioned above. It is used behind cover whenever possible and entirely concealed from the enemy, and with it an area of ground can be swept with shell in width and length with ease and accuracy. The work, moreover, is done with great rapidity, 20 rounds a minute being fired, and every shell placed so accurately that the whole of the ground is covered with the minimum amount of ammunition. To attain this speed of firing the ammunition wagon is brought alongside the gun, and tilted backwards round its axle, so that the cartridges lie nearly horizontally and each may be taken from its

pigeon-hole more easily than a book from a book-case. The sides of the wagon and the doors are of thin armour-plate, the latter, when open, forming wings to protect the men serving the gun. Further, delay and errors in setting the time fuses by hand are avoided, as this is done instantaneously by means of a special fuse punching machine. This device is furnished with a corrector for taking account of the atmosphere and other conditions which may prevail at the time. The French attach great importance to the rapid opening of fire, and provide instruments to facilitate this and to correct any initial errors immediately the effect of the first shots is noted.

Time will not permit me to enter into greater detail, but what I have said is sufficient to show that the French, in introducing the modern field gun, made radical departures from the previous practice of any country. When the gun was issued to the troops it was subjected to severe criticism by experts on the ground that it was too delicate and complicated for field service, and that it would entail a great waste of ammunition. However, its qualities are now generally recognised, and every country has since built weapons on similar lines.

The field gun of the English Army is of the wire wound construction with an inner tube of nickel steel. It is of 3·3 inches calibre, and throws an 18½ lb. shell with an initial velocity of 1,610 feet per second. The breech action is of single motion screw type with a repeating trip lock. The gun is guided by two longitudinal guide ribs, and recoils on a bronze cradle, the trunnions of which are inclined to the horizontal in order to compensate for the mean angle of drift. The trail is formed of a cylindrical steel tube and terminates in a spade, the latter being without the horizontal flange, which is adopted, and I think rightly, by the French. A hydraulic buffer lying above the gun checks the recoil, and surrounding the buffer are telescopic springs for running out the gun automatically after firing. The lowness of the gun obtained by this arrangement is favourable to its stability, but the buffer springs are rather exposed to the enemy's fire. Moreover, lowness must not be carried too far, because of the danger of injury to the chase when crossing ditches and rocky ground. The French gun, it will be remembered, is mounted above the recoil and running out mechanism, but the extra height is neutralised to a slight extent by making the wheels

some four inches less in diameter than is the English standard practice. As to the relative advantages of springs and compressed air for running out, I am inclined to prefer the latter. Springs are heavy, and if they fail, are difficult to obtain in time of war. Air, on the contrary, costs nothing, and by pumping a little more into the cylinder the running up force may be accurately adjusted to the highest angles of fire, or increased to compensate for any extra friction of the gun in its slides.

The English gun with its cradle, is mounted on a sort of turntable on the axle, on which it is traversed for direction. The traversing mechanism is thus very simple and light to handle, but at the limit of traverse there is an angle between the direction of recoil and the plane of the wheels, which involves a tendency to shift the gun sideways. Scotching is dispensed with by the English authorities, and I think they are justified in considering the operation unnecessary. Independent sighting is adopted on the English field gun, the left hand trunnion of the cradle carrying a telescope and open sight, pivoted so that it can be traversed horizontally. The elevating mechanism is on the right hand side, and the angle of elevation above the horizontal line is recorded on a drum calibrated in yards of range. It seems to me questionable whether telescopic sights are necessary or advisable for field guns, as the conditions are entirely different to those prevailing in naval warfare.

The shield of the English gun consists of two portions, the lower of which is hinged up when the gun is not in use. The upper part is curved backwards, and affords more protection to the men than the French shield. The service of the gun is practically identical in the two armies, except that the English practice is for the layer to do the firing. The ammunition wagon is not made to tip up but is opened from the rear, the door hanging down to protect the legs of the men. The fixed ammunition is held in cells of basket work, while the French wagons are fitted with metallic bearers for the ammunition which would seem much more efficient in preventing injury to the thin cartridge cases. The device for setting the time-fuses does not appear to permit of setting being done with the same rapidity and certainty as the plan adopted by the French. This is a very important point, as upon it naturally depends very largely the efficiency of the firing.

Of the mountain guns, siege guns, howitzers and similar weapons, I need not speak, as where French and English practice differ with regard to them, the points of difference will be understood from what I have said respecting field guns.

In drawing this address to a conclusion, I am aware that there are many points of interest which I have not touched upon, and others which deserve more discussion than I have been able to give them. But an attempt to deal at all exhaustively with the subject of guns and ammunition, in one short evening, is out of the question. The field is too broad for more than a hasty survey, and if I have interested you in this most interesting branch of engineering, I shall feel that my object has been realised. I may have seemed critical at times, and have not hesitated to express my opinion on some very controversial matters, but I have endeavoured to be just to both sides.

My interest in guns is now purely a scientific one, and my sympathies are with what seems to me to be the best engineering —whether found on this side of the channel or the other. There are often, however, many different ways of obtaining a result, and all equally good, though custom and long familiarity with one may make it appear preferable to any other. I am no longer young enough to think that those who differ from me on any point are necessarily wrong, and I trust that I have said nothing this evening which could possibly be taken as a disparagement of other men's work, or a reflection upon the services of either country. In fact, I would rather record my admiration for the unremitting attention which the engineers and technical officers of both England and France give to the improvement of armament for the defence of their respective territories. Their responsibility is exceedingly great, and although they may differ in opinion as to details, we may be confident that they each and all agree in striving for the honour of the services in which they are interested. May it be long before the war equipment of either of our great nations is put to the supreme test, and may the day never dawn when there is a thought of comparing them in a less friendly manner than I have done to-night.

MEETING OF MEMBERS AT COVENTRY.

A meeting of tne Coventry members and their friends was held at the residence of Mr. H. H. Thorne, 7 Ford Street, on Monday evening, 18th November, 1907, when there was an attendance of 16.

The chair was taken at 7.30 p.m. by Capt. P. Robinson-Embury, R.E., who announced that the communication to be presented was the Inaugural Address of that well known engineer, M. Gustave Canet, the subject being "Some Comparisons between French and English Artillery."

Before proceeding to read the Address, Mr. Thorne briefly explained the constitution and objects of the Institution, and intimated that it was the desire of the members in Coventry to so increase their number as to be able to form a local section there, and so not only strengtnen the Institution, but benefit engineers now resident in Coventry, and those who might come amongst them from time to time from other places.

At the conclusion of the reading of the Address the Chairman of the meeting made a few appropriate remarks with reference to the subject dealt with, and on the motion of Mr. Thorne, seconded by Mr. King, a vote of thanks was passed with great applause to M. Canet for his most excellent contribution.

A vote of thanks was also passed to Captain Embury for presiding on the occasion, and several visitors expressed their appreciation of the invitation which had enabled them to spend such an enjoyable evening.

MEETING OF MEMBERS AT BIRMINGHAM.

The first meeting of the Birmingham members and their friends took place on Monday evening, 18th November, 1907, at the Headquarters of the Birmingham detachment of the Electrical Engineers Volunteers, John Bright Street, by kind permission of Lieut. J. F. Lister, E.E. Vols., in the absence of whom, due to an accident, the chair was taken by Mr. E. A. Dowson (Member). There were five members and eight visitors present.

The Chairman, in opening the proceedings, made a few remarks on the advantages which membership of the Institution offered, and went on to refer to the life work of the new President, M. Canet, as an artillerist, which had made his name so famed.

Mr. R. B. A. Ellis then read the President's Inaugural Address on "Some Comparisons between French and English Artillery," and at its conclusion, on the motion of Mr. E. J. Jewell, seconded by Mr. M. R. Parker, a cordial vote of thanks was passed to the President for it.

The hearty thanks of the meeting were also expressed in acknowledgment of all that Mr. Ellis had done in connection with the occasion.

VISIT: BLACKFRIARS BRIDGE WIDENING WORKS.

The Second Visit of the Twenty-seventh Session took place on Saturday, 26th October, 1907, at 2.30 p.m., to the Blackfriars Bridge Widening Works for the London County Council Tramways, by permission of the Engineer for the works, Mr. Basil P. Mott, M.Inst.C.E. The attendance was 91.

The members were received by the Resident Engineer, Mr. David Anderson, and Mr. H. Cunningham, Engineer for the Contractors, Sir William Arrol and Co.

With the aid of the working drawings, which were displayed on the walls of the office, the method of carrying out the work was first fully explained, and the members were then conducted across the bridge to view the actual operations. One of the pier caissons was seen on the staging being got ready for the process of sinking on to the bed of the river, and other interesting features were pointed out.

The Chairman, Mr. F. R. Durham, expressed the members' acknowledgments of all the facilities which had been kindly extended in the arrangements for the visit, and Mr. Anderson replied.

For the following particulars of the work and the accompanying illustrative blocks, the Institution is indebted to the proprietors of "Engineering." At page 72 of the issue of that journal for 18th January, 1907, appear reproductions of drawings giving elevations, cross sections and other views of the work.

The work in connection with the widening of Blackfriars Bridge was formally inaugurated on 3rd July last, when the first of the caissons was lowered on to the bed of the river from the stage on which it was constructed. The contract for the work

was let to Sir William Arrol and Co., Ltd., of Glasgow, for slightly over £200,000, with a penalty of £20 for each and every day occupied upon the work in excess of the contract time of three years, and a premium of the same amount for each day under this time.

The widening work necessitates first an extension of each pier and abutment at its western or upper end. The existing western fascia and parapet will be removed, and three additional steel ribs, at 10 feet centres, will be built, the general construction corresponding to the existing work.

These additional ribs will increase the width by 30 feet, making the distance between the parapets 105 feet, which will make Blackfriars Bridge the widest bridge over the River Thames. There will be a roadway of 73 feet, with a footpath on each side of 16 feet. The tramway will be laid on the western side of the roadway.

Perhaps, however, the most interesting part of the undertaking will consist in the construction of foundations; but in view of the immense experience of Sir William Arrol and Co., in this particular class of work, such difficulties as may arise will certainly be overcome. It will be remembered that they sank caissons of 70 feet in diameter for the piers of the Forth Bridge to a depth of from 70 feet to 90 feet below high-water level. In the case of the Caledonian Railway Bridge over the Clyde, the caissons were sunk 70 feet below high-water level. They have also worked down to 85 feet in the same river for the piers of a new bridge. They worked to a depth of 65 feet on the Tyne for the piers of the Redheugh Bridge, and to 75 feet on the Wear, for the bridge now being built at Sunderland. The Nile Bridge piers at Cairo were carried to a corresponding depth. In the case of the piers for the bridge over the River Barrow, near Waterford, the caissons were sunk to 115 feet below high-water level, the maximum air-pressure under which the men worked being 43·5 lbs. per square inch above atmosphere. This is the deepest foundation sunk in Great Britain under air-pressure; but so admirable were the arrangements that no trouble arose.

The method adopted at the Blackfriars Bridge is shown in the accompanying illustrations, and it is creditable to the firm that, in view of the extensive traffic, passenger and vehicular, and the importance of maintaining the amenities of the district, they

have dispensed entirely with steam power, so that there may be no smoke nuisance. The air-compressing engines for providing pressure within the caisson are electrically driven with current from the public supply mains. The riveting is largely done by pneumatic tools, and there are electric cranes and hoists for raising the excavated material from the working chamber in the caisson, and for lowering the cement concrete for filling in the caisson, as well as for dealing with the masonry and members of the superstructure.

Fig. 1 is a plan at the Embankment end of the bridge, showing the area of the timber staging put in the river, which, it will be noted, involves the minimum of interference with the traffic. As shown in Fig. 2, the caisson is suspended by links from hydraulic jacks used for the lowering operation. Fig. 3 shows the caisson as it appears when it enters the bed of the river. Fig. 4 shows it at its ultimate depth, with the air locks in position.

The caisson is first built on staging with a deck about 5 feet above high water level. Care is taken that the cutting edge on the blocks is as nearly as possible over the position that the caisson will occupy when lowered to the river bed. The working chamber is riveted and caulked, and the roof girders fixed in position, so that the height of the steelwork is then about 13 feet. Strong timber trestles support two pairs of steel girders a few feet above the caisson. On these girders rest the hydraulic lowering jacks, four in number, one near each end of each pair of girders. These jacks have hollow rams, which allow the lowering links to pass vertically upwards through their centres. The links are flat steel bars about 10 feet in length, the links being alternately double and single, to allow of ease and rapidity in joining the parts together. Slot holes are provided in the links, pitched at the same distance apart as the stroke of the ram of the jack—12 inches. The lower ends of the links terminate in jaws, which engage, by means of pins, with brackets bolted to the permanent structure of the caisson.

When the caisson is ready for lowering, it is raised off the building blocks, and lowered in successive stages of 12 inches to a convenient level for completing the upper parts. A cotter is placed in the slot hole immediately above each ram; water is pumped into the cylinders under the rams which then rise, and,

engaging with the cotters, raise the whole caisson sufficiently to allow of the blocks and staging immediately below to be removed. A second cotter is placed in each lowering link through the slot immediately above the one at the ram. On letting the water escape from underneath the rams the caisson is lowered about 12 inches, and the last mentioned cotter is engaged with a saddle fixed on the top of each jack; the cotter immediately above the ram is freed and placed in the next slot hole higher up; the ram is again pumped up to the lower cotter, thus freeing the higher one, which is shifted up to another hole. The water is again allowed to escape, and lowering takes place to the same extent as before. The operation can be repeated any number of times. Additional strakes of steel shell plating are added to the body of the caisson, as required, during the period of lowering.

Before being lowered to the bed of the river, the caisson has its shoe filled in with concrete. After the caisson has reached the bottom, the lowering gear—timber trestles, girders, jacks and hoists—removed, and the temporary caisson erected on the top to exclude the tidal water, the concreting of the caisson is proceeded with until it reaches the top of the permanent portion, after which the air is pumped into the working chamber, expelling the water and enabling the men to descend the shaft, on which the air-locks have been previously fitted.

The excavated material is hoisted through the same shaft in buckets by means of gear attached to the material lock, and driven by electric power. When the caisson has reached the full depth to which it has to be sunk (about 27 feet below low water) cement concrete, mixed on the staging above, is lowered to the working chamber, and packed and rammed all round the sides until the chamber is completely filled with concrete. Any crevices remaining are thoroughly filled with liquid grout, and the upper portions of the tube, together with the air-locks, having been removed, the shaft is itself filled up with concrete. The foundation is then ready to undergo its test load prior to the commencement of building operations upon it.

When the foundation described above is ready to receive its masonry, it will be necessary to make the temporary steel caisson and the sides of the existing piers form part of the same enclosure, and to remove the side of the temporary caisson next

the pier, to allow of the new masonry and that removed from the present piers being built upon the new foundation. This is to be effected by forming a timber cofferdam puddled with clay on each side of each pier, partly overlapping, on one hand the steel caisson, and on the other, the face of the old pier masonry at a point beyond where it has to be removed for rebuilding. These dams being completed, the enclosed space will be pumped dry, and the operations inside will proceed.

Set in the heart of the new portion of each pier will be two long steel trusses to bind the new and old structures securely together, and, at the same time, to carry the skewbacks for the new steel ribs, which are to support the superstructure forming the increased width of the pier. After the masonry portions to a point above high water have been completed, the temporary caisson and dams will be removed, and the superstructure proceeded with.

It will be matter for general regret that Sir Benjamin Baker has not lived to see the inauguration of another of his great projects. He prepared the parliamentary and constructional plans, but before his death the actual work of carrying out the scheme had been transferred to Mr. Basil Mott, M.Inst.C.E., with whom is associated Mr. E. M. Wood, Bridge Engineer to the late Sir Benjamin Baker.

[*See over for plates.*]

VISIT: BLACKFRIARS BRIDGE WIDENING WORKS.

Fig. 1. Plan at Embankment end of Bridge.

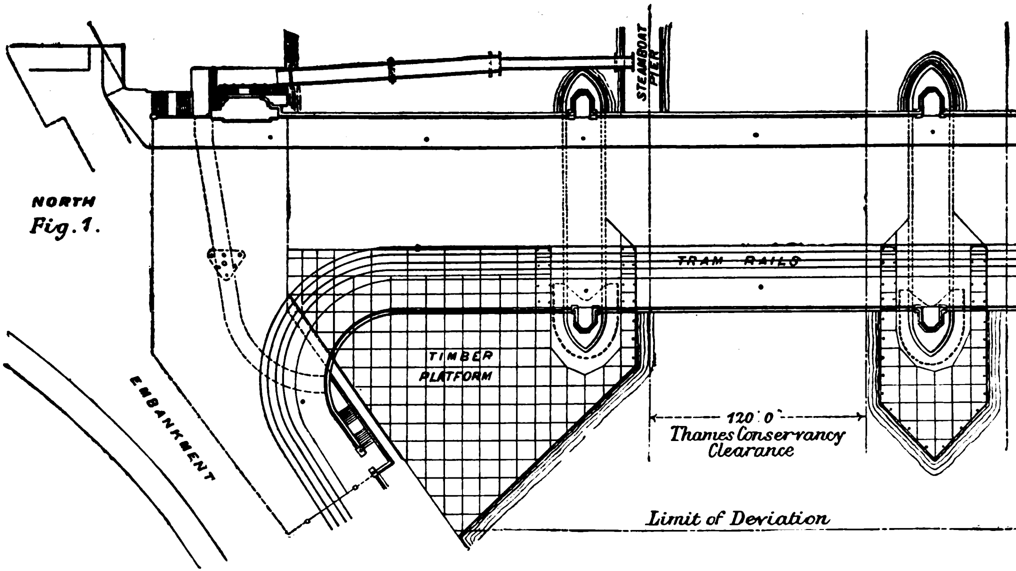

Fig. 1.

PLATE 1.

VISIT: BLACKFRIARS BRIDGE WIDENING WORKS.

Method of Sinking the Caissons.

PLATE 2.

Fig. 2.

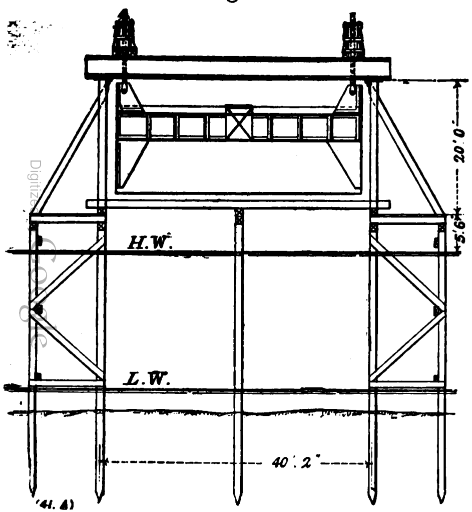

Fig. 3.

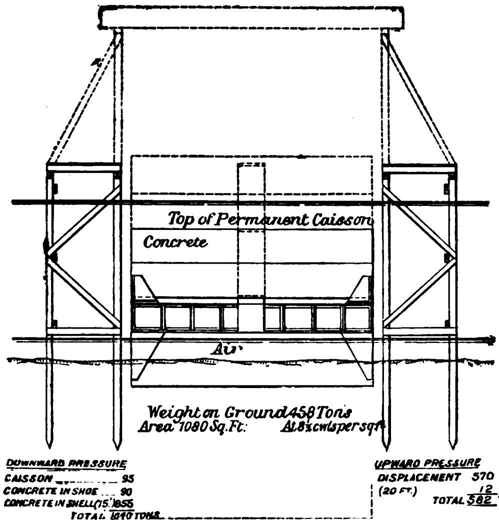

Fig. 4.

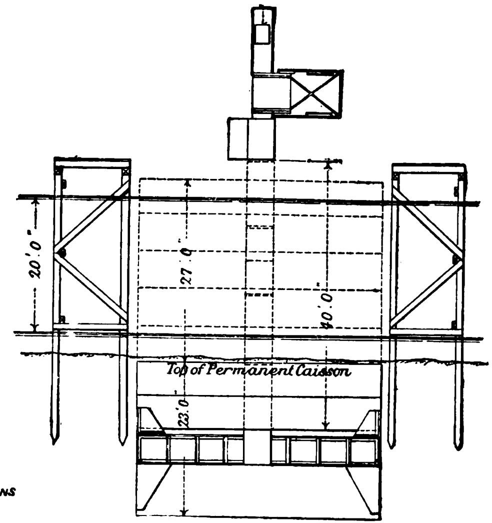

PLATE 2.

Part 4. **JANUARY, 1908.** **Vol. XVIII.**

The Junior Institution of Engineers
(Incorporated).

President - - M. GUSTAVE CANET.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

1st January, 1908.

ANNOUNCEMENTS.

WEDNESDAY, 8th January. Meeting at 8 p.m. at the Society of Arts, John Street, Adelphi (turning from Adam Street, Strand). A Paper on "**The Conduit System of Electric Tramway Construction, and Recent Improvements**" by MR. FITZROY ROOSE, L.C.C. Engineer's Department, will be read and discussed.

SATURDAY AFTERNOON, 11th January. Visit, by permission of the Chief Engineer, Mr. Maurice Fitzmaurice, C.M.G., the **London County Council Tramway Reconstruction Works** in course of progress in South Lambeth Road, under the guidance of the Resident Engineer, Mr. Alexander Millar, and Mr. Fitz Roy Roose; and the **Clapham Road Motor School, Car Shed and Sub-Station,** under the guidance of Mr. A. L. C. Fell, Chief Officer. Members to assemble **at 3 p.m.** at the corner of South Lambeth Road, opposite Stockwell Station of the City and South London Railway. They will afterwards proceed by tramcar down Clapham Road to the car sheds, &c., in High Street, near Clapham Common. Take ticket to "The Plough." [N.B.—The Camberwell Depôt will not be visited.]

FRIDAY, 7th February, at 8 p.m. An Extra Meeting will be held at The Royal United Service Institution, Whitehall. A paper on "**Aerial Navigation**" by MR. HERBERT CHATLEY, B.SC.ENG., will be read and discussed.

The President, **M. Gustave Canet,** will take the chair at this meeting, and some of the well-known workers on the problem of aerial flight are expected to assist in the discussion.

SATURDAY, 8th February, at 6.30 for 7 p.m. Anniversary Dinne at the **Hotel Cecil, Strand,** the President, **M. Gustave Canet,** in the Chair.

WEDNESDAY, 12th February, 7.30 p.m. Joint Meeting with the Discussion Section of the Architectural Association at **12 Tufton Street, Westminster.** A paper entitled "**Suggestions as to how the Architect and Engineer may combine,**" by MR. PERCY J. WALDRAM (Past Chairman J.I.E.), will be read and discussed.

THURSDAY, 20th February. Meeting at 8 p.m. at the **Royal United Service Institution, Whitehall,** a paper entitled "**Practical Notes on the Testing of Gas Engines,**" by MR. GILBERT WHALLEY (*Member of Council*), will be read and discussed.

SATURDAY, 22nd February, at 3 p.m. Visit to King's College, Strand, for inspection of **Experimental Apparatus, &c.,** to be shown by Professor D. S. Capper (*Hon. Member*), Professor of Mechanical Engineering.

CHANGE OF MEETING PLACE. After the meeting on 8th January, which will be held at the Society of Arts, future meetings of the Institution will take place at **The Royal United Service Institution, Whitehall** (by permission of the Council), on the dates already announced, with the exception of that of the April meeting, which will be **Tuesday, 7th April,** in place of Monday, 6th April.

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

BROWN, JOHN JAMES NESBIT; Ocean Accident and Guarantee Corporation, 36-44 Moorgate Court, London, E.C.

DREW, JOHN HENRY; Surveyor's Office, Urban District Council of Audenshaw, 2 Guide Lane, Audenshaw.

JACKSON, HERBERT WILLIAM; Tool Department, Coventry Ordnance Works, Coventry.

LANCASTER, SIDNEY DAVID; Commercial Gas Company's Works, Stepney, E.

MILTON, GEORGE HART; Messrs. Brett's Patent Sifter Co., Coventry

ROBERTSON, THOMAS EDWARD; British Thomson-Houston Co., 83 Cannon Street, London, E.C.

SWAIN, FRANK REGINALD; 19 Emperor's Gate, London, S.W.

WALLIS, JAMES; Messrs. L. Whitehead and Co., Portland Place North, Clapham Road, S.W.

WALTER, SYDNEY JAMES; Messrs. Davis and Walter, 134 Fleet Street, London, E.C.

WATSON, THOMAS AUBREY; Messrs. Holloway Bros., Ltd., 19-21 Belvedere Road, Lambeth, S.E.

Proposed for election to the class of "Associate."

COOK, JOHN WILLIAM DONALD; District Railway Works, Ealing Common, W.

HAYBITTEL, LESLIE MCGOWAN; Messrs. Anson and Shenton, 28 Victoria Street, Westminster.

HUNTINGFORD, ERNEST SYDNEY; Messrs. Arnold Goodwin and Son, 56 Sumner Street, Southwark, S.E.

JOCKEL, LAURET MARSHALL; Messrs. Bertrams, Ltd., Sciennes, Edinburgh.

NAIDU, CUPPERSAWNY NAIDU VARADA RAJATU; Public Works Department, Erode, Madras.

PATERSON, ANGUS NEIL; Messrs. Fraser and Chalmers, Erith, Kent.

TAYLOR, GEORGE; Messrs. H. Young and Co., Nine Elms Iron Works, Nine Elms, S.W.

VICKERS, CHARLES FRED; Engineering Department, Thames Ironworks Shipbuilding and Engineering Works, Greenwich, S.E.

PERSONAL NOTES.

ROBERT BAKER, who is engaged on the Kowloon Canton Railway, China, has been promoted from the position of Personal Assistant to the Chief Engineer, to that of District Engineer.

GEORGE BAILEY has left England to take up the duties of Assistant Manager of the properties of the African Gold Dredging and Mining Concessions, Ltd., on the Ancobra River, Axim, Gold Coast Colony.

THOMAS T. BAINS has been selected for the appointment of Surveyor to the Rural District Council of Shields. He was for more than twenty years in the service of the South Shields Corporation.

PHILIP P. BROWN has been elected an Associate Member of the Institution of Civil Engineers, having passed the final examination in October last.

RAYMOND CORREA is now with the General Electric Co., Peel Works, Salford, Manchester.

E. HAY CURRIE has been appointed Engineer-in-charge on the construction of a railway in the vicinity of Mendoza, and is at present carrying out a large survey for branch lines. Address: Via 7 Obras, F.C.G.O.A., Mendoza, Argentina.

SAMUEL CUTLER, jun. *(Past Chairman)*, has been elected Member of Council of the Society of Engineers.

H. O. ETHERIDGE, of the P. W. D. Kuching, Sarawak, via Singapore, is expected home shortly.

L. M. DE G. FERREIRA has been elected, without examination, an Associate Member of the Institution of Civil Engineers.

THOMAS GERMANN, with Mr. S. M. Hills as co-author, read before the Northampton Institute Engineering Society "Some Notes on Insulation and Insulation Testing." They also contributed to "Electrical Engineering," of 28th November, an article on "A Method of Measuring Dielectric Strength."

R. H. HAMMERSLEY HEENAN (*Hon. Member*), who recently retired from the position of General Manager and Engineer-in-Chief to the Table Bay Harbour and Docks, under the Cape Government, has opened an office for Messrs. Heenan and Froude at 56 Victoria Street, Westminster.

H. C. B. HICKLING wrote from Bundi, Straits Settlements, on the 28th October, that he hoped to be in England soon.

JOHN H. DAVY JAMES sailed from Southampton on the 7th December for South Africa. Address: c/o Mr. S. H. Spray, Box 224, Germiston, Transvaal.

R. SETON LOGAN, c/o W. S. Boyd, Customs House, Montreal, wrote on 1st December, strongly advising that no member should leave for Canada unless he had secured an appointment before sailing. There was little prospect of a revival of trade until next April.

ALFRED MATTHEWS, from Carlton Colville, near Lowestoft, is now with the Printing Appliances and Engineering Co., of 3 Rosebery Avenue, London, E.C.

P. W. McDOUGALL has been appointed Electric Supply Engineer to the British Electric Federation, Donnington House, Norfolk Street, Strand, W.C.

J. H. RADCLIFFE has become London agent to Messrs. Wm. Wilson and Co., Boiler makers, of Lilly Bank Boiler Works, Glasgow; his office being at 1 Monument Street, E.C.

W. H. STACEY has left England for Singapore, having been appointed Chief Engineer there for Messrs. John Aird and Co., on the Tanjong Pagar Dock Works.

Appointments.

108. A young engineer with some knowledge of chemistry is required in a London office. Preferably one who has passed through technical college course with success.

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213. Member, age 26, Assoc.M.Inst.C.E., Contructional Engineer, desires appointment as Assistant Works Manager. Eight years' experience in all branches of high-class structural steel and bridge work.

214. Member, age 28, desires engagement as Assistant to Consulting Engineers, or responsible position in works. Good draughtsman, varied experience and used to superintending work.

215. Member, age 29, seeks position as draughtsman or engineer, London preferred. Seven years' experience in the design and manufacture of motor cars, and six years marine work with shop experience.

216. Member who has served articles and had five years' municipal and contractor's experience, desires change as draughtsman in Engineer and Surveyor's office. Excellent references.

Changes of Address.

BRIGGS, C. T., 4 Connaught Gardens, Forest Hall, Northumberland.

BURMEISTER, T., 181 Amesbury Avenue, Streatham Hill, S.W.

FAWKES, A. W. E., c/o Messrs. Fawkes and Sons, 660 Dundas Street, London, Ontario, Canada.

HOSEGOOD, T. P., 42 Monmouth Road, Bishopston, Bristol.

MACFARLANE, J. B., 7 Lawrence Pountney Hill, Cannon Street, E.C.

MOLLER, E. J., 6 Henderson Road, Wandsworth Common, S.W.

POPE, E. F. T., 4 Narcissus Road, West Hampstead.

RELTON, T. H., 32 Golden Hillock Road, Small Heath, Birmingham.

STANGER-LEATHES, L. G., 104 Bristol Road, Birmingham.

WHITBY, E. C., 144 Kinfauns Road, Goodmayes, Ilford, Essex.

YOUNG, W. E., "Claremont," Cowes, Isle of Wight.

FROM THE STARTING PLATFORM.

WIND PRESSURE.

The second part of the research on the estimation of the wind pressure on structures in progress at The National Physical Laboratory, has been completed, and the results of the experiments were given in a paper read before The Institution of Civil Engineers on the third of last month. The first part of the research, published in 1904, dealt with experiments on small plates and models placed in an experimental channel 24 inches in diameter, through which was passed a current of air having a velocity practically constant across the channel. The results obtained were in general agreement with those of previous experimenters, the chief characteristic being that the resistance of the plates used, which did not exceed 5 square inches in area, was from 7 to 10 per cent. lower per unit area than that determined for plates of 1 square foot in area by Messrs. Dines, Froude and Langley.

In 1904, the experiments in the open air were commenced. A steel windmill tower, 50 feet high, was erected in the grounds of The National Physical Laboratory, and pressure boards ranging up to 100 square feet in area were exposed to the action of the wind by attaching them to a revolvable framework on the top of the tower.

The only previous experiments which had been made with boards of this size were those carried out by the late Sir Benjamin Baker, in 1884, during the construction of the Forth Bridge.* In these experiments one pressure board was 300 square feet in area, and another $1\frac{1}{2}$ square feet. It was found that in the average gale the *maximum* recorded pressure per unit area of the large board was always considerably lower than the *maximum* recorded pressure per unit area of the small board. The mean of Sir Benjamin Baker's published results gave a pressure on the small board which is 50 per cent. greater than that on the large board. Experiments made by Mr. W. H. Dines in 1890, by balancing the wind pressure on a large board by that on a smaller board, appeared to show that this difference always existed throughout the gale, and was not merely a maximum effect. This would mean that the difference was purely an effect of the dimensions of the boards, whereas Sir Benjamin Baker's explanation of his results was based on the want of uniformity in the velocity of the wind over any considerable area at any instant.

As it was possible that the difference in resistance might be due both to dimensions of board and to structure of the wind, and as the determination of the relative magnitude of those two factors was all important, it was decided to investigate this question as thoroughly as possible at the National Physical Laboratory.

The method adopted was to take a large number of observations for each board of (1) resultant pressure, and (2) square of velocity of wind (simultaneously estimated). These were plotted, and the mean relation between pressure and square of the velocity obtained. The results for three boards, one 25 square feet in area, one 50 square feet, and one 100 square feet, gave practically identical values of the constant K in the pressure velocity relation

$$P = K V^2$$

from which the conclusion was drawn that since the *mean* values

* See Adam Hunter's Paper, Vol. XVII., page 203.

of the resistance of these boards were the same, the effect of dimensions for this range in area was very small.

Further observations led to the conclusion that there was a definite dimensional effect on the resistance, amounting to an increase of 18 per cent. in the resistance of boards of 50 square feet in area, over that of plates of a few square inches, but that this difference did not increase uniformly with the dimensions, being practically confined in the case of square plates to the range between linear dimensions of 12 inches and 2 inches.

The general results of the experiments in the open air showed that the resistance of any structure, however complicated, can be predicted, for any given velocity, from experiments on small scale models of the structure in a current of air.

There remains for the purpose of the designer the prediction of the maximum value to be assigned to the velocity in the above relation, which will depend on the locality and size of the structure, and which will form the final stage of the research.

T. E. STANTON.

KELVIN.

Lord Kelvin, O.M., who became a Vice-President of the Junior Institution of Engineers in June, 1895, died at Largs, N.B., on 17th December, 1907, in his 84th year.

He is mourned by the whole world of science.

The Junior Engineers, second to none in their reverence for the might of that tremendous intellect, greatly appreciated the opportunity afforded them at Glasgow, in 1896, of meeting their great senior. He attended the Summer Dinner and responded to the toast of "The University of Glasgow," proposed by the kindly and popular "Archie" Denny, who was our President at that date.

Afterwards we felt a kind of filial or proprietary regard for our illustrious Vice-President, which we have reason to think was reciprocated.

In 1896 we addressed him upon the attainment of the Jubilee of his Professorship of Natural Philosophy in the University of Glasgow. His reply may be found on page 23 of Volume VII. of the Transactions.

In 1904 the Institution was represented at the installation of Lord Kelvin as Chancellor of the University of Glasgow.

During our "Coming-of-Age" celebration in 1905, we telegraphed congratulations to him on the eighty-first anniversary of his birthday. An immediate reply brought us: "Hearty thanks for kind congratulations on my birthday. Please accept reciprocal congratulations on 'Coming-of-Age' of your Institution, and best wishes for its success."

And this morning (Monday, 23rd December) a few of our officers attended the final ceremony at Westminster, sharing in a scene to which the Abbey formed a most impressive setting. The gloom of the day heightened the solemnity of the service, which, as is usual with the services conducted there, was magnificently rendered.

Lord Kelvin was a fairly frequent visitor to the Royal Institution, and anyone observing him could not fail to note his vivid and almost boy-like interest in whatever instruments were on the lecture-table, familiar though all apparatus for experimental physics must have been to him.

The present writer had always to repress an instinctive tendency to rise, as for Royalty, upon the entry of that famous figure, active in spite of its weight of honourable years and a slight limp caused by an accident and nowise due to infirmity.

So much has already been written elsewhere on the work and inventions of Lord Kelvin that it is not necessary to set down more in this place. But a moment's thought will bring home to one the enormous economic value of his life's work.

The results of this work have long provided the wherewithal for the daily needs of many a Junior, and for the well-being of multitudes of others who have not the distinction of being numbered upon our roll.

His labours will not cease to be fruitful though they are stilled, and his name will be renowned generations hence, a gem in the diadem of science. The Abbey receives his mortal remains; but that "he being dead yet speaketh" will long be true of him.

To Lady Kelvin the Institution offers the respectful sympathy of the whole of its members.

W. J. T.

OBSERVATIONS IN GENERAL.

It was interesting to notice the announcement in the current session's programme of the Architectural Association Discussion Section that a Paper was to be read by Mr. H. Rofe on "Water Supply for Country Houses," on Wednesday, 15th January, at the Association's headquarters at 18 Tufton Street, Westminster.

* * * * * *

We understand, however, that Mr. Rofe, owing to unforeseen circumstances, has been prevented from writing his promised treatise.

* * * * * *

At the request of our Architectural *confréres*, our Chairman, Mr. Durham, has, at short notice, kindly undertaken to deputize, and, having regard to the special knowledge of the subject of water supply which he possesses, we venture to predict that his paper will be found of considerable value both to the architect and the engineer.

* * * * * *

The Architects, in gratefully acknowledging the help they thus receive in their difficulty, cordially invite any of our members who can do so to attend the meeting in question, to be held as above. It opens at the hour of 7.30 p.m. Tickets may be obtained from our Secretary.

* * * * * *

Our members will unite in offering to Sir John Durston, K.C.B., their warmest wishes for his happiness on the occasion of his retirement from the post of Engineer-in-Chief of the Navy, after eighteen years' service in that capacity.

* * * * * *

Sir John commenced his career as a fitter apprentice in Portsmouth Dockyard, entered the naval service in 1866, became Chief Engineer in 1877, and Engineer-in-Chief of the Fleet twenty-two years later.

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As noticed in our issue of January, 1906, Sir John was specially promoted to the rank of Engineer-Vice-Admiral, the highest rank which could be awarded the Engineer-in-Chief. It was in 1893 that he became an Honorary Member of the Institution.

He is succeeded at the Admiralty by Engineer-Vice-Admiral H. J. Oram, C.B.

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Our Coventry members, and especially Mr. Thorne, merit an expression of commendation for their efforts with a view to increasing the membership in directing attention to the advantages the Institution offers.

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Not only do they foregather with their friends—members in embryo—for the reading and discussion of the papers presented in London; they have recently held a whist drive, and most successful it is reported to have been; Mr. Thorne, with mathematical precision, recording the attendance 7^2. A favourable opportunity occurred during the evening for the objects of the Institution to be dilated upon, and an invitation to the ensuing technical assembly to be given.

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Lord Rayleigh, O.M. (Vice-President), at the last election continued in office as President of the Royal Society. The Hon. C. A. Parsons, C.B. (Past-President), was elected a Member of the Council.

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Professor T. Hudson Beare (Hon. Member), in his address as President of the Royal Scottish Society of Arts, Edinburgh, dealt with the subject of "Some Notable Events in the Engineering World during the Session 1906-7," the Quebec Bridge disaster and the two turbine Cunarders receiving especial notice.

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Two others of our Honorary Members have also recently been elected to the position of President, Mr. Joseph William Wilson becoming President of the Society of Engineers and Mr. Henry Adams President of the Institute of Sanitary Engineers.

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The extra meeting of the Institution, which the Council have arranged for Friday, 7th February, will no doubt prove exceptionally attractive, the subject for consideration being as it is, "Aerial Navigation," with the President in the chair, and also with the expectation of seeing and hearing some of those who have made their names notable in the aeronautic world as investigators and experimentalists.

We notice that at the last distribution of awards by the Institution of Civil Engineers, Mr. Dugald Clerk (Past-President) received a Telford premium for his Paper on "The Limits of Thermal Efficiency in Internal Combustion Motors."

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What a very creditable first number is that of the Finsbury Technical College Old Students Association Magazine, published last month under the editorship of our Past-Chairman, Mr. W. J. Tennant. Well written, well printed, and in every particular just as one would have expected to find a production for which W. J. T. was responsible. An excellently executed portrait of Dr. M. O. Forster, F.R.S., the first President of the Association, 1906-7, is issued as a supplement with it.

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Surely, with the knowledge of this Magazine and all it portrays before him, every Old Finsburian who is not yet enrolled (both day and evening men are eligible) will be sending in his name to one of the Hon. Secretaries, Mr. S. E. Gritton (Mechanical), Telfourd Cottage, Reigate, Surrey; Mr. E. W. Moss (Electrical), 20 Huddleston Road, Tufnell Park, N., or Mr. F. H. Carr (Chemical), "Kelvin," Church Avenue, Sidcup, Kent. All that is asked in the way of subscription is a modest five shillings per annum to members within thirty miles of headquarters and half that amount to all others.

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"The Starting Platform" is this month occupied by Dr. Stanton, Superintendent of the Engineering Department of the National Physical Laboratory, who has, at the request of the Director, Dr. R. T. Glazebrook (Vice-President of the Institution), kindly written a *résumè* of the experiments on wind pressure, the results of which Dr. Stanton presented in his Paper to the Institution of Civil Engineers last month.

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After Mr. Adam Hunter's adjurations on the subject from a constructional engineer's point of view, which were set forth in his Paper to our Institution in December, 1906, the record of these experiments will be read with great interest.

NOTES AND QUERIES.

10.—RUNNING OF LARGE INDUCTION MOTORS.

The trouble complained of is almost certainly evidence of poor mechanical design of the machines in question. It looks as if the shafts were not stiff enough, for no reasonable amount of wear in the bearings could allow the rotor to touch the stator, provided the shaft does not bend. Furthermore, no measurable wear should take place if the bearings are suitable and the lubrication maintained. Steam turbine practice amply confirms this statement. A weak shaft will both cause undue wear in the bearings, and will allow the rotor to be pulled into contact when there is very little want of centrality. An initial air gap of one-tenth of an inch, or even less, would be reasonable for induction motors of the size specified, and with such a gap there should be none of the trouble mentioned. With smaller gaps the shaft should be correspondingly stiffer. With existing machines it is difficult to see what can be done except to take care of the adjustment of the bearings, but the attention of the designer should be called to the question of stiffness.

R. H. Parsons.

11.—VICTORIA FALLS ON THE ZAMBEZI.

In reply to members who have asked what the object is beneath the girders shown in the photograph taken during the construction of the Victoria Falls Bridge, facing page 20 of *The Journal* for October, 1907, it should be stated that it consists of netting suspended from the booms to receive any tools, &c., which might fall during the process of erection.—Ed.

VISIT TO THE ROYAL ARSENAL, WOOLWICH.

The Third Visit of the Twenty-seventh Session took place on Saturday morning, 23rd November, 1907, to the Royal Arsenal, Woolwich, the party, 102 in number, assembling at the Main Gates at 10 a.m.

Mr. H. F. Donaldson, M.Inst.C.E., Chief Superintendent of Ordnance Factories, received the members; and under the guidance of the Chief Mechanical Engineer, Mr. Douglas Heap, M.Inst.C.E., and other officials, they were conducted round in

small divisions. Mr. F. R. Durham, Chairman, conveyed the Institution's acknowledgments of the kindness shown by Mr. Donaldson in making special arrangements enabling the members to see so much in the limited time at disposal.

For the following particulars and accompanying plan the Institution is also indebted to Mr. Donaldson.

Historical.—It is probable that the Romans had a settlement hereabouts, for fragments of pottery of their design and other evidences of their occupation have been unearthed in the neighbourhood, whilst in the Royal Arsenal itself two funereal vases of undoubted Roman manufacture were dug up during the progress of excavations in the Dial Square in the year 1856. These vases are now preserved in the Royal Artillery Institution.

There are fairly reliable records of the Tenth Century which imply that Woolwich was an agricultural, if not a fishing, village, and Domesday Book mentions it and the surrounding districts.

Until comparatively recent times Woolwich was more celebrated for its Dockyard than for its Arsenal, and during the reign of James I. and subsequently, many of the largest warships of the British Navy were built here. The Dockyard, however, ceased to exist as such in 1869, and its buildings have since been utilised by various branches of the Military service as storehouses and workshops.

There are no very reliable records as to the population in earlier days, but in 1851 Woolwich contained about 27,000 civilian inhabitants. A large increase took place during the period of the Crimean War, from 1854 to 1856, since when there have been alternating periods of prosperity and depression, but in the main a steady growth. At the present time the population of the Borough of Woolwich (which includes the contiguous parishes of Plumstead and Eltham) amounts to roughly 127,000.

The North Kent Railway from London Bridge to Woolwich was opened in 1849. It was preceded by a branch of the Eastern Counties Railway to North Woolwich in 1846.

Being the home of the Royal Artillery and the centre of various Government Establishments, Woolwich has had associations with many celebrities. Among its more distinguished natives may be mentioned Lovelace the poet, Charles Gordon, of Chinese and Khartoum fame—whose brother, Sir H. W. Gordon, was at one

time Controller in the Royal Arsenal—and Maudslay, the engineer and inventor, who was born within a stone's throw of the Arsenal in which he afterwards worked.

In the police lobby at the Entrance Gates there is an inscription which relates that "This Entrance to the Royal Arsenal was planned and this Gateway constructed by order of General Viscount Beresford, G.C.B., G.C.H., Master General of the Ordnance, in the tenth year of the reign of His Majesty King George the Fourth, A.D., 1829."

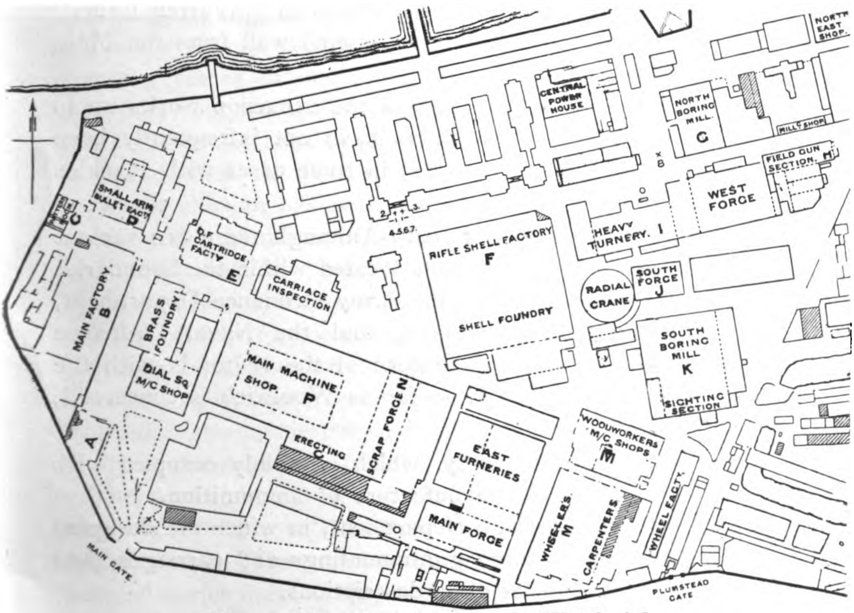
On the enclosure in front of the Chief Superintendent's Office stands a brass culverin brought from Malta. It is a handsome gun, 19 feet long, of 6-inch calibre, and weighs 115½ cwt. It is ornamented with figures of Cherubim and Saint Michael the Archangel, and bears an inscription in Latin to the effect that it was "made in the year 1607, in the time of the Grand Conservator Brother Michael de Lentom out of the perpetual income derived from the estate of Modica established by Brother Raymond de Veri of Majorca, bailiff in the year 1590, and registered by Brother Raymond de Berga, Grand Conservator." The brass carriage on which the gun is mounted was made in the Royal Arsenal in 1827.

Looking north is seen the Dial Square, one of the oldest portions of the Arsenal. The sun dial over its gateway is dated 1764. On the right are the Ordnance Committee Offices, formerly occupied as quarters by the Director General of Artillery, and beyond them, blocks of quarters which a hundred and fifty years ago were Artillery barracks. On the left is the portico of the old guard room, before which, and beneath the elm trees that used to stand there, the Royal Artillery Band played in former times during the relief of the guard.

Near the Machine Shop is the building once used as a school for the instruction of Arsenal boys in the rudiments of elementary education, and some yards further on the Arsenal Hospital, which is staffed and equipped for rendering the best surgical and medical aid to injured and sick employees.

It is not easy to assign even an approximate date to the original foundation of the Royal Arsenal. There is, however, no doubt that the Royal Carriage Department and Royal Laboratory existed in embryo in the Seventeenth Century, and that ordnance were proved here at the same period.

On the site now occupied by the Pattern Room for Laboratory Stores (see building marked "C" on plan) it is probable that a building existed as far back as the Fourteenth Century. This building came into the possession of the Government about the middle of the Sixteenth Century, and was occupied by the Master General of the Ordnance, a position held for some years by Prince Rupert. Incidentally, it may be observed that the present Arsenal wharf is built on an old river-side terrace formerly known as Prince Rupert's Walk. The existing Laboratory Pattern Room was erected in 1719 from designs by the famous architect, Sir John Vanbrugh. It was for some years used as a place of instruction for the Royal Artillery cadets. Adjoining the building was a tower, pulled down in 1786. (An old print showing this tower may be seen by the visitor at the further end of the Pattern Room.)



Plan of the Royal Arsenal, Woolwich.

In 1716 the casting of ordnance was removed from Moorfields to Woolwich, and the old Brass Foundry, now used as a Tinmen's Shop, was then erected, in which to carry on the work. This foundry (marked "A" on the plan) is also said to have been built to the design of Sir John Vanbrugh, and its quaint porch will be

seen by the visitor on his left hand just prior to entering the first of the workshops included in the usual tour of inspection. The official who was then responsible for the manufacture of guns, called the Proof Master, occupied a residence alongside the foundry, and over one of its doors was placed a handsome stained glass window, which has since been removed to the new offices of the Chief Superintendent of Ordnance Factories. This window is supposed to represent King Edward III. with a group of his officials examining one of the guns cast in Woolwich Arsenal, but it will be noted that this would carry back the manufacture of guns at Woolwich to a date long anterior to any of which we have an authentic record.

The description "Royal Arsenal" was first given to the establishment in 1805. Prior to that it was known as the "Royal Warren," and in still earlier times as "Woolwich Tower Place." The former designation is still perpetuated in "Warren Lane," a thoroughfare running outside the Arsenal wall from the Main Gate towards the river.

Convict labour was largely used in the extension works up to 1856, and the remains of prisoners have not infrequently been found in the course of excavations, in some cases with shackles still attached.

Establishments of the Arsenal.—Although there are various Military and Naval Establishments located within the boundaries of the Royal Arsenal, such as the Army Ordnance Department, the Army Inspection Department, and the Naval Ordnance Department, the immediate concern of the visitor is with the Ordnance Factories. These, so far as Woolwich is concerned, comprise:—

(*a*) The Royal Laboratory, which is mainly occupied with the design and manufacture of ammunition.

(*b*) The Royal Carriage Department, in which are designed and manufactured gun-mountings and carriages, and military vehicles of all descriptions.

(*c*) The Royal Gun Factory, in which guns and torpedoes are designed and manufactured.

(*d*) The Building Works Department, which constructs and maintains all Arsenal buildings, roads and railways, and supplies electric and hydraulic power and gas.

These, with the Gunpowder Factory at Waltham Abbey and

the Small Arms Factory at Enfield Lock, constitute what are collectively known as the Royal Ordnance Factories.

Area, &c.—The extreme length and maximum breadth of the Arsenal are rather more than three miles and one mile respectively. Its total area amounts to about 1,285 acres, of which 407 acres are contained within the boundary walls and 89 acres are covered with buildings. The capital value of the factory buildings on 31st March, 1906, exceeded three quarters of a million pounds.

Railways.—For the transport of stores and material there are 15 miles of broad gauge railway, served by 19 locomotives, chiefly of the 4-wheel coupled type, and 300 wagons; also 32 miles of narrow gauge railway, served by 40 steam and 5 oil locomotives and 986 trucks. The points and crossings number 1,200.

A properly organised passenger service is also a feature of this railway system. Working to a regulated time table, with ten stopping places en route, there are fourteen trains daily in each direction from end to end of the Arsenal. It will be realised that the provision of such accommodation effects a very considerable saving of time in traversing the somewhat extended distances to which allusion has been made above.

Along the main avenues within the Arsenal asphalt tracks for cycle traffic have also been laid down and are largely used.

Machinery.—The capital value of the machinery installed in the Woolwich Factories on 31st March, 1906, amounted to £610,000. In addition to the plant provided for actual manufacturing operations, there are 415 cranes and lifts worked by hydraulic, steam, electric and hand power; also a large number of hydraulic capstans, presses, accumulators, &c.

The prime movers in use include 100 boilers and 68 steam engines, having a total horse power of 9,700.

Employees.—The number of persons employed in the Royal Arsenal varies considerably according to circumstances. During the busiest period (1901) of the South African War the numbers exceeded 11,000 in the Royal Laboratory, 3,700 in the Royal Carriage Department, 3,500 in the Royal Gun Factory, and 2,400 in the Building Works and Central Departments. The average total number employed in these Departments during the ten years ending 1906 was roughly 16,000.

The working hours, regulated by what is known as the 48 hours' system, are from 8 a.m. to 1 p.m., and from 2 p.m. to 5.40 p.m. daily, except on Saturdays, when work ceases at 12.40 p.m. It will be seen that under this system there is but one break during the day, and it has been found that practically the same output is obtained and the same wages are earned as under the former 54 hours' system, when work began at 6 a.m., with intervals of one hour for breakfast and one hour for dinner.

(A) ROYAL LABORATORY.

Main Factory.—In the Royal Laboratory are manufactured ammunition of all kinds, including shells from 1 inch to 17·72 inches in diameter; fuzes by which the shells are detonated and known as "time" or "percussion," as they determine the time or place of explosion; cartridges ranging from the small ·303 inch for rifles to the large self-contained cartridges for quick-firing guns; rockets and tubes. A large number of the metal components required for these stores and also the metal cases for packing ammunition are made in the main factory. It contains 600 machine tools, amongst which special attention may be drawn to some 80 automatic machines of the most modern types. These machines are so designed that, with a minimum amount of personal attention, they will, from plain bar, produce components in a finished condition.

Pattern Room.—Here is to be seen a very interesting collection of warlike stores, dating from the early days of ordnance manufacture. The building in which these articles are located is on the site of the house referred to previously in these notes as having been occupied by Prince Rupert. In the room on the left-hand side of the main entrance hall are patterns of many kinds of stores for the information and guidance of possible contractors.

Small Arms Bullet Factory.—In this shop is carried on the manufacture of bullets for rifles. These bullets consist of a soft lead core and an envelope. The former gives sufficient weight to allow the bullet to carry the required range and assists in keeping it stable during flight, and the latter, made sufficiently hard to take the rifling in the barrel of the gun, causes the bullet to rotate and gives stability and low trajectory.

In the manufacture of the soft cores, lead of a particular composition is placed in hydraulic presses, whence it is squirted in the form of rod and cut into lengths as required.

The envelopes are punched from long thin strips of material and are gradually pressed and drawn until they attain the required dimensions and shape. The core and envelope are then brought together to form the completed bullet.

Quick-Firing Cartridge Factory.—The term "quick-firing" refers to a type of gun and ammunition which allows a very much faster rate of firing to be maintained in the smaller guns than was possible with the old type of gun ammunition. So far as the ammunition itself is concerned, it involves the use of an explosive charge already made up and ready for insertion in the breech of the gun. These charges are usually contained in brass cases, and the system is really an extension to large ammunition of the usual design of small arms ammunition.

The production of "Q.F. cases," as they are commonly called, comprises:—(1) Mixing and casting ingots of special composition. (2) Rolling these ingots into strips. (3) Punching the strips into blanks or round discs of various sizes and thicknesses. (4) Converting the blanks into "cups." (5) Elongating the cups by the process of drawing, the number of "draws" varying with the sizes to be produced. (6) Heading or forming the shoulders on the drawn cases, together with trimming and subsequent minor machine operations.

It will be readily understood that this series of operations, by which an original blank, say about $\frac{3}{4}$ inch thick by 8 inches diameter, is successively drawn until it becomes a cylindrical case, say 18 inches long by 5 inches or 6 inches internal diameter, with one end closed and having head and shoulders $\frac{1}{4}$ inch thick and the walls themselves only about $\frac{1}{20}$ inch thick, necessitates very severe treatment to the metal, and to enable it to satisfactorily undergo these operations it has to be thoroughly annealed at the various stages of manufacture.

The machinery used is mostly hydraulic, the pressure ranging up to three tons per square inch, the actual pressures required to carry out some of the operations being as much as 1,200 tons.

In an annexe some of the preliminary operations of casting and rolling the metal are performed, and on the upper floor the machining operations necessary to complete the cases and to produce the smaller components such as anvils, caps, &c., are carried out.

Shell Foundry.—In this department the bodies of the various natures of shot and shell are produced, and pass through the requisite operations preparatory to being filled with explosive charges or fitted into quick-firing cartridges.

The equipment comprises eleven cupolas for the production of iron castings and molten iron for conversion to steel, a number of underground furnaces for the production of cast crucible steel shell of any special character, and three Tropenas converters for the production of the larger sizes of cast steel shell. These Tropenas converters might probably be mistaken by the casual observer for Bessemer furnaces. The Tropenas process, however, is held to be an improvement on the old Bessemer system of steel production, and is of comparatively recent origin. It was adopted in the Shell Foundry in 1897, the installation being one of the first of its kind in this country. The molten pig iron, containing perhaps, 4 per cent. to 5 per cent. of carbon, is poured into the converter, which is then up-ended and great volumes of air are blown in just underneath and on the top of the surface of the molten metal, which results in combustion of the carbon taking place. After from fifteen to twenty minutes, practically the whole of the carbon in the molten metal is burnt out, leaving only a very mild form of cast steel. The particular moment at which the whole of the carbon is burnt out is very well marked, as the flame which was previously shooting from the top of the converter suddenly drops, indicating that there is no more combustible matter or carbon present. The converter is then turned down and certain ingredients termed "physic" are added according to the particular nature of steel it is desired to produce. It is then turned up again, and when the "physic" has been thoroughly incorporated and combined with the molten metal, the converter is again turned down and the charge poured into a ladle, whence it is taken by electric crane to the casting pits and poured into the moulds prepared for it.

It may be mentioned that the West Gate of the Foundry is an extremely fine example of cast iron work.

Emerging once more into the open, there will be seen, in a space on the left-hand side ("8" on plan), an instrument of warfare almost unique, viz., a mortar, intended by its inventor, Mr. Mallet, to fire projectiles 3 feet in diameter. It was primarily intended for use against the Russian fortifications during the

Crimean War. Two of these mortars were made by the special orders of Lord Palmerston, but they were never used for the purpose intended. One was, however, tested at Woolwich, and threw a shot weighing over a ton a distance of a mile and a half.

(B) ROYAL CARRIAGE DEPARTMENT.

In this Department gun mountings, field carriages, and military vehicles of every description are manufactured and repaired. It still employs many woodworkers, although, so far as gun carriages are concerned, steel has largely displaced timber for constructive purposes. Ammunition and rifle cases and other miscellaneous stores are also made here.

Wheel Factory.—In the Wheel Factory some of the most modern and ingenious machines in use in this country for wheel construction have been introduced. Amongst others, the spoke-turning, throating and facing machines are conspicuous, whilst those for felloe turning, rounding, and polishing, are also noticeable. The various parts of the wheel are assembled by means of hydraulic presses. This machinery is also utilised for making heel pegs, tent poles, mallets, &c.

Carpenters' Shop.—The plant here includes the felloe bending machine and the hydraulic presses for clamping together boxes and chests, also special machinery for small arm ammunition boxes.

Wheelers' Shop.—Here will usually be found in various stages of construction or repair, examples of many military wagons, carts and limbers.

Wood Machine Shop.—This shop is filled with sawing, planing, boring, multiple drilling, mortising, tenoning and machines for dovetailing, the latter process being particularly interesting, and performed with the greatest rapidity. In accordance with modern practice, the machines in this shop are driven from underground, and shavings, chips, and dust, are also drawn away underground by means of exhaust ducts.

In the Scrap Forge will be seen a 7 ton steam hammer, a horizontal and vertical hydraulic press and a rolling mill. In the Erecting Shop are usually to be found large garrison and naval mountings in various stages of erection.

Main Machine Shop.—The tools in this section are among the largest of their kind in the Royal Arsenal, and many of the

operations performed by them approximate more to ordinary engineering work than do those of the tools in any of the other shops.

(C) ROYAL GUN FACTORY.

North Boring Mill.—This is one of the older sections of the Royal Gun Factory, wherein is carried on the manufacture of guns of all classes and calibres, except small arm rifles and machine guns. Those actually turned out at the present time vary in calibre, or diameter of internal bore, from 3 inches up to the latest type of 12 inch rifled gun with a length of 45 feet. The weight of these weapons, without accessories, ranges from 3 cwt. to 60 tons. Ordnance of larger calibre and considerably heavier weight were manufactured in former years, but they have been superseded by the modern gun of smaller calibre, greater length, and very much higher muzzle velocity and penetrating power.

The machine tools here are, on the whole, of a very much larger type than those in the other departments of the Royal Arsenal, and therefore lend themselves very readily to single or group electric motor driving. There are in the department at the present time (1907) about 180 electric motors, with an aggregate horse power of 2,800, ranging in size up to 100 H.P., and run, for the most part, from electric supply mains having a voltage of 300 volts. Steps are being taken to convert the current to 500 volts for power purposes on the three wire system, leaving 250 volts available between two wires for lighting purposes. The current is supplied from a central power station for the Arsenal generally. Considerable use is made in this factory of magnetic clutches. It is interesting to note that the Gun Factory Boring Mills were worked by horses up to as recently as 1842.

Field Gun Section.—In this section are manufactured the lighter mobile guns used by the Horse and Field Artillery. Milling and grinding machines play a very large and important part in the operations on these guns, and, in the case of many of the smaller components, magnetic chucks or holders are used.

Main Turnery.—Many large machine tools are here installed for the special operations incidental to the manufacture of guns.

Forge.—The plant here includes the large 40 ton steam hammer, striking a blow equal to about 1,000 tons steady

pressure. This hammer, when first erected, was quite unique in its way, but here, as in many other engineering works, the steam hammer of abnormal size has been superseded owing to the superior utility of the hydraulic forging press, a fine example of which is to be seen in the West Forge. The press in question can exert a pressure on large forgings of 3,000 tons, and turns out better and more uniform work than a steam hammer does.

South Boring Mill.—Here are carried on the various operations of rifling large guns and also the subsequent lapping, gauging, and inspection of the same. When the gun is fired, a copper band surrounding the base of the projectile is forced into the spiral grooves of the rifling causing the projectile to revolve on its longer axis and steadying it in its flight. Up to about 1856 all guns were smooth bore.

The machine tools in this shop are, in the majority of cases, quite special to the particular operations of gun manufacture, and are mostly driven by individual electric motors.

In the South Boring Mill attention is directed to the process of strengthening guns by means of wire wound round the inner tube. The wire employed for this purpose is of rectangular section, and many miles of it wound in successive layers at regulated tensions are used in the construction of a large gun.

NOTES ON ARC LIGHTING.

The Third Ordinary Meeting of the Twenty-seventh Session was held at the Society of Arts, John Street, Adelphi, on Tuesday, 10th December, 1907, the attendance being 70.

The chair was taken at 8 p.m. by Mr. Frank R. Durham (Chairman), and the minutes of the previous meeting of 18th November last were read, confirmed and signed.

A paper, "Some Notes on Arc Lighting," was read by Mr. William Krause (Member).

The discussion upon it was opened by Mr. A. W. Marshall, who also proposed a vote of thanks to the author for his paper. The motion was seconded by Mr. C. H. Smith, who continued the discussion, and was carried by acclamation. The other speakers were Messrs. H. E. Angold, M. H. Hankin, C. G. Evans,

Bernard Brooks, F. D. G. Napier, W. Hogg, A. H. Stanley, R. H. Parsons, and the Chairman.

The author having replied, the proceedings terminated with the announcement of the ensuing visits on 14th December to Shepherd's Bush, to the site of the Franco-British Exhibition, the Exhibition Extension Works of the Central London Railway, and the Central London Railway Power House; and of the ensuing meeting on 8th January, when a paper on "The Conduit System of Electric Tramway Construction, and Recent Improvements," would be read by Mr. Fitz Roy Roose, of the London County Council Engineer's Department.

"SOME NOTES ON ARC LIGHTING,"

By WILLIAM KRAUSE (Member).

Read 10th December, 1907.

The year 1896 may be taken as the commencement of a period of comparative success for arc lighting. The arc lamp had then proved itself reliable as a light giver, so far as things mundane are reliable, and in the struggle for supremacy with its only serious rival—coal gas—was fast progressing to the important position it now holds among the many systems of artificial lighting.

Some idea of the position of the arc lamp in this respect may be gathered from its increasing demand for public lighting. Statistics compiled from the station list published with the "Electrical Review" of the 1st May, 1896, show that of 123 stations in the United Kingdom making returns relating to both privately and municipally owned undertakings, 73 reported a total of 2,260 in use. Unfortunately, the returns given regarding the arc lamp for private lighting are too often cited as equal to so many 8 c.p. incandescent lamps, that for purposes of arriving at the actual number, or for making comparisons, they are entirely useless. Some few only mention arc lamps as in use for public lighting, without recording any details, so that the total number of lamps in service must have been in excess of that given. The author believes he is very near the truth when he places the total number then in use in round figures at 3,000. The bulk of these were direct-current, and were run in high tension series from an arc lighter, a series-wound constant current dynamo, generally of the Brush or Thomson-Houston type. The alternating current stations in some few instances were sending their current through a Ferranti rectifier, and thereby approximating to a direct or continuous current, the current becoming a series of pulsations of like sign. Alternate current lamps were not much in use, and were mainly of the open type, and ran either with a separate transformer, or choking coil, off the low pressure mains.

Features of open and enclosed types.—The main features of the two types of arc lamps in use in 1896—(1) the open, and (2) the

enclosed—may be briefly described as follows :—In the open type, which was by far the more common, the arc burned as though in the open air, the lantern or globe serving mainly as a protection from disturbing air currents, weather, &c., or if an opalescent globe, only for diffusing the light, or rendering it less piercing. The effect of the globe on the regulation of the lamps was almost nil, and according to the closeness of the globe fitting, added but one or two hours to the time of burning of a 16-hour lamp. The construction of this type was confined to three main classes: (1) The British, having the well-known solenoid and rocking bar; (2) the American, with the straight pull and clutch; (3) the Continental, in which the solenoid is replaced by an electro magnet and generally a clock escapement gear. Some British manufacturers were still using carbons of unequal length, and of almost similar diameter—viz., 13 mm. and 11 mm. respectively for a 10 amp. lamp, although the Continental method was being rapidly adopted by others, viz., that of using carbons of equal length, but the sectional area of the positive twice that of the negative, a 10 ampere lamp being trimmed with 18 and 13 mm. carbons respectively.

In the enclosed type of lamp the arc burned in a glass chamber so arranged that the atmosphere was almost excluded. These lamps were all made under the "Jandus" patent, and were what is known as the "Double Enclosure" type, the inner globe being surrounded by another serving the same purpose as that on the open type. The point aimed at was essentially one of long burning, an average of 200 hours being attained. The mean hemispherical candle power as compared with that of the open type was as regards white light, about 30 per cent. less for equal watt consumption and with clear inner globe only; the general quality of the light, however, was not to be compared with that of the open type lamp. It showed a similar spectrum because of the incandescent carbon, but had such an extent of violet rays from the long arc in excess of that required for lighting as to border on the ghastly. The lamps were constructed, as they are now, with self-contained line resistance, to run direct on 100-110 volts, or two in series on 200-240 volts, consuming in the direct current lamp 5 amperes, with 80 to 85 volts across the arc, and in the alternating current 6 to 7 amperes with 65 to 75 volts across the arc, and usually with a separate choking coil.

Compared with the lamps of to-day, they were very unsteady, and fits of pumping were common.

Of the lamps still in the embryo state in 1896, probably the only one to call for any attention is that of the semi-incandescent type, which was designed in several forms, and proved most efficient, not so much by reason of the incandescent properties of the refractory material within which the arc burned, as through the enriching of the arc itself by the volatilisation of that envelope. It is interesting in so far that it was a forerunner of the metallic flame lamp, by which its future development is now completely closed.

Development of the open type.—Reverting to the open type of lamp in 1896, and comparing it with that of the present day, it may be said that no important changes have been made in its construction, and that it remains practically what it was ten years ago. Improvements other than those due to the discarding of rubber as a suitable brake material, and the substituting of metal in various forms, have been along the lines of compensation for wear in the feeding mechanism, and in the matter of safety devices dealing with the prevention of over-heating of the shunt coil and the automatic cutting out of the lamp, owing to failure.

The working range of current for an open type lamp, as determined by practical experience, is between the limits of 7 and 15 amperes. Below the lower limit, the light efficiency falls off rapidly; and, what is of more importance in the eyes of the average consumer, the lamp loses that brightness and brilliancy which one is accustomed to associate with an electric lamp. The overall dimensions being determined by the period of burning required, are approximately the same for equal hours of burning for a 5 as for a 20 ampere lamp; while in the case of a 5 ampere arc, the light is out of all proportion to what appears by contrast a formidable piece of apparatus. Above 15 amperes the light becomes too concentrated as a single unit for ordinary lighting purposes, while above 20 amperes the arc becomes unsteady and increasingly so as the current rises, or as the line or balancing resistance as it is also called, is decreased, until with a terminal pressure of 50 volts, and a current of 30 amperes and over, the "rushes" of current are such as to break the points of the carbons.

As regards the extent to which the development has been

carried, it has never really got beyond the twin-carbon stage, although many multiple types were constructed, but these brought with them such complications as to render their manufacture unprofitable. For internal lighting, compared with the modern enclosed lamp, the open type, although more efficient in candle power per watt, is nevertheless inferior in diffusing the light, and more cumbersome for a shorter burning length. The longest burning on a single trim with a twin or double carbon lamp is 32 to 34 hours at 12 amperes, using 20 and 30 mm. carbons 12 inches long. With 10 amperes the period may be extended to 40 hours, but the light is considerably diminished, owing to the carbons being of too large a diameter.

On the Continent, wherever 110 volt circuits are in vogue, it is a common practice to run three lamps in series; these, however, require starting with a stepped resistance. This system does not appear to have received much favour here, probably because of the shortness and low efficiency of each separate arc, resulting in a poor appearance compared with lamps running with well-formed arcs.

The development of the application of the open type arc is apparent from the extraordinary increase in the number of lamps for public lighting. By the year 1903, out of 322 stations making returns, 291 reported its use for this purpose, aggregating a total of 17,209, London alone contributing 5,138. It should be stated, however, that in some instances the returns given include a number of the enclosed type of lamp, but this is comparatively small. The number has been so steadily rising, that by 1907, out of 428 stations giving returns, 280 reported public arc lighting, with a total of 23,134 lamps, which also include some of the enclosed type, and a few flame lamps. The last two years have, however, witnessed a remarkable falling off in the demand for the open type lamp, mainly with respect to private use, in fact, its zenith was reached in 1906, and there are at present indications that this type of lamp will eventually become quite obsolete.

The enclosed lamp.—It has already been mentioned that there was a double enclosure lamp in existence in the year 1896. This was mainly devoted to internal lighting, or used in places where there was any difficulty of access, and to some extent for outside

lighting by those who desired such lamps, because of their novelty.

During the next two or three years many improvements were made, chiefly in the method of enclosing, or in the globe fitting, and in various devices in the regulating mechanism; but these improvements alone would not have brought the lamp to its present position, especially when the extensive adoption of the incandescent gas mantle is borne in mind, although the writer regards that as but a passing expedient, and accepted solely because of its cheapness, the light emitted not being perfect in quality. The light of the long-burning enclosed lamp was not a white light, and therefore, would have succumbed to the open type before very long, but, as often happens when two systems are in competition, each possessing an advantage not held by its rival, a compromise was effected, or a merging of the two, with some loss to the dominant feature of each, and with a mutual gain greater than that of their combined loss. The objectionable feature was removed from the long-burning double enclosed lamp by increasing the rate of combustion of the carbons, and by allowing more air to be admitted, but at the expense of the long period of burning—the average run being reduced varying from 80 to 120 hours—according to the size of the globe. So that in the case of a direct current lamp, a light was obtained very closely resembling that of the open type.

Important changes were yet to follow. The enclosed lamps were being made under patents, the essentials of which embodied a double enclosure, or an inner chamber, but experience taught that the inner chamber could be employed out of doors when the outer was too badly cracked to be put over; while indoors also, it was found that an improvement in the light could be obtained by the removal of the outer globe.

It was but a short step to make the enclosing globe of opalescent material in order to diffuse the light, and so dispense with the outer globe entirely, thereby gaining 10 to 40 per cent. in light efficiency. It had already been done in some instances in order to absorb some of the violet rays, and, by the way, resulting in an absorption of 30 per cent. of the white.

That is the position to-day; except in very exposed places the double enclosure is not required, the single enclosure giving a light, which, while not equal to that of an open-type lamp con-

suming the same wattage, yet surpasses it by reason of its better diffusion.

Considerable improvement has been made during the last few years in the controlling mechanism of the enclosed lamps. The earlier devices were based almost entirely upon those employed in the open type, and were in most instances unsuitable. With increased experience, however, new methods were adopted, and, as in the case of the thermal control or hot wire lamp, systems quite unsuitable for the open type were operating successfully on the enclosed.

Compared with magnetic control, the hot wire is very sluggish, as can be easily proved by comparing the sensitiveness of the Cardew meter with that of a moving coil instrument. It has also for this reason been employed in an overload release for motor controllers. That its adoption was possible on the enclosed type of lamp, while unsuited to the open type, is probably due to the sensitiveness of the feed following the x^2 law. A rough idea may be gleaned from the fact that with a 10 ampere open type lamp burning Siemens' "A" 18 and 12 mm. carbons with 36 volts across, shortening the arc one mm. caused a drop of two volts, while with a 50 volt arc, the difference caused was almost unappreciable on the same instrument, thereby showing why an enclosed lamp with its longer arc can be worked with a much coarser feed than one of the open type. Another point is that the variations in light are not so readily seen in the enclosed as in the open, firstly, because of the brighter appearance of the globe, and secondly, on account of a partial obscuring of the crater by the negative. As the arc is shortened in the open type lamp the angle of maximum intensity with the horizontal is altered, and causes at any point of the maximum light zone, a variation apart from that due to the actual change in the current.

Where the thermal control is used on the alternating current, a considerably better regulation is maintained, due to the constant tremor caused by the arc, which, except for spluttering due to carbon inequalities, is absent in the direct current arc. An important feature of the thermal control is the absence of a shunt coil, or shunt control. Because of their longer burning hours enclosed lamps are more often inadvertently left on open circuits than are those of the open type, and are therefore more

likely to have their shunt coils destroyed, so that the elimination of the coil in that type of lamp is a distinct step in the right direction.

The regulation in the thermal control is effected solely by the variation of the resistance of the arc, causing a change in the current, and therefore an expansion or contraction in a metal strip whose varying length is used to release or tighten the clutch holding up the carbon. The shunt coil, however, is not a necessity where a lamp is to run in single parallel; it would ensure a finer feed, but is unnecessary in an enclosed arc. Single parallel lamps have for many years been made with only one series coil. Were two such lamps connected in series, however, the smallest difference in their feeding point would ultimately result in uneven burning of the arcs, there being no compensating attachment.

It is possible to so construct lamps that when running in series no appreciable difference in their light will be noticeable at the end of the first hour. If then the arc be re-struck, an operation, which, with carbon ends already hot, and surrounded by the arc gases, occupies but one-tenth to one-twentieth of a second, the carbons are restored to their original distance from each other, continue burning, and this process is automatically repeated until the carbons are consumed. (Many hot wire lamps are at present running satisfactorily enough in series, simply because of the short period of each run.)

To effect the process described above in a lamp having a magnetic control, one method is to construct the core in two parts, arranged so that it descends to a little less than is required to burn the prescribed length of carbon. When the upper part reaches a stop as the lower still descends, the core separates, causing a weakening of the field, so that the bottom part controlling the carbon falls and re-strikes the arc.

In another method, also of the magnetic control type, a descending core actuates the feed until the desired point is reached, when the mechanism attached to the core is arrested by a trip lever, and the carbon, instead of remaining stationary, is made to lift by the still descending core, with the result that the arc is quickly broken, thus avoiding any lengthy period of a weakening light; the last action of the core is to push away the trip lever, when the carbon falls and the cycle re-commences.

There can be no doubt that for internal lighting the enclosed lamp will hold the field for many years to come. At the present time it is doing indoors what the metallic flame lamp is doing outdoors—displacing the open type arc; although there is one system that will probably continue—lighting by means of the inverted arc, so notable from its effect in producing such a close imitation of daylight. As all the light is reflected before it falls upon the surrounding objects, any colour in it can be absorbed or toned as desired, a slightly creamy tint sufficing to produce a perfectly white light, but the cost of the system at present is prohibitive, being 30 to 50 per cent. more than that of direct lighting. A very good approximation to the same result, however, can be secured with direct current enclosed lamps, and as improvements are continually being made in the direction of obtaining as small a unit of light consistent with the steadiness and efficiency of the lamp, possibilities of improvements in the lighting of interiors will follow also.

Carbons.—For many years there have been endeavours to vary the colour of the light given by the carbons of the arc lamp. The mixing of soda with the carbon, and the insertion of hydro-carbons in the core, to render the light more fog penetrating, comprised some of the earlier efforts. The author remembers using in 1896, a core composed of strontium nitrate, alternating with baryta to vary the colour of the arc, but with somewhat startling results.

Probably one of the earliest British patents was granted to Tabulevitch, in December, 1896, for the use of carbon and steel as a negative, and the adding of pyrotechnic salt to the positive to colour the arc. That of Waddington, of March, 1898, expressly mentions "To increase and colour the light for use in search lights, and to render same more capable of penetrating fog," requiring the employment of strontia, soda or plaster of Paris, rammed into holes bored into the carbons.

That the arc should remain centred in the core is of far more importance than that the feed should be fine or uniform. The mean length of a converging type arc is from 1 inch to $1\frac{1}{4}$ inch, with 8 amperes and 40 volts across, while that of a plain carbon arc is $\frac{3}{16}$ inch for the same current and voltage. So long as the arc contains the volatilised metallic salt, the feed may be coarse compared with that of the plain carbon arc, and is analogous in

that respect to the enclosed arc, but directly it leaves the core for the carbon envelope, its properties become altered, and approach those of the plain carbon arc.

If the carbons are arranged vertically, a rough approximation may be formed of the difference in the light-giving power of the flame and open systems, but no such idea can be formed when the carbons are of the converging type, as the arc burns nearly horizontally, having its angle of maximum intensity turned through an angle of 90 degrees or more nearly, as a cone of light having its axis lying at 20 degrees with the horizontal; even so the light is wholly obscured in a vertical direction, the fall in intensity being such that the lamp may be considered practically out. For the arc to remain a metallic flame arc, it is essential that the carbon envelope should burn away at the same rate as the core.

The rate of consumption of a pair of carbons, however, is influenced greatly by the economiser, or half open chamber, within which the combustion takes place, according as the points be raised or lowered within it. In the case of a direct current, the difficulties are further increased by reason of the rate of combustion of the negative—usually a plain cored carbon—decreasing at a greater rate than the positive, while they are both raised in the economiser. What is first of all required then, is a pair of carbons made with sufficient accuracy to burn evenly in a fixed position on a line drawn vertically through the economiser; to maintain this position is the function of the arc lamp mechanism.

So far, the bulk of the flame lamps at present in use here are of Continental manufacture, and have, as with the open type, Continental characteristics, being similar to the open type mechanism, except that a much longer strike is required in the vertical type; while in the converging type, the long arc is produced with a blow magnet placed over the arc in such a manner that its magnetic field encroaches upon that of the arc, thereby forcing it downwards and compelling it to take a crescent-like form.

In order to ensure a steady burning, it is necessary to make the carbons of small diameter, with the resulting disadvantage that the rate of consumption of carbons is increased proportionally, and consequently the resistance also. It has therefore been found necessary to either coat the carbons with metal or to intro-

duce a metal wire in the core, the latter giving by far the better results.

The resistance of a 10 amp. lamp varies approximately 1 ohm. per foot per pair—using 7 and 8 mm. non-metal cored carbons.

Owing to the great difference in the cost of carbons having a metal core, compared with those having only a plain salted one, several arc lamp makers have brought out a lamp in which the carbons are fed from a magazine holding as many as 8 pairs, and thereby increasing the burning length of the lamp from 45 to 55 hours. The difficulty experienced up to the present is the same as with other flame lamps, *i.e.* the deposit of the metallic oxides in the interior. It seems almost impossible to exclude them altogether, so that attempts are now being made to make the feeding mechanism self-cleaning.

Comparison of M.H.C.P.—In comparing the mean hemispherical candle power of different types of lamps it must be borne in mind that the measure of utility depends upon the angle at which the maximum light is transmitted, and also upon the nature of the surroundings to be lighted. The mean hemispherical candle power from an arc consuming 500 watts, is in the enclosed lamp 600 to 700; in the open type 1,200 to 1,300, and in the flame arc 2,000 to 3,000, according to the kind of carbons used. In each case the angle of maximum intensity is different; that of the enclosed being 20 to 30 degrees below the horizontal—depending upon the height of the arc in the globe—and emitting above the horizontal about 25 per cent., which makes it useful in toning down the shadows in internal lighting. The open type has its maximum intensity between 40 to 50 degrees, the light above the horizontal not being worth considering; while that of the flame lamp being very much narrowed—being below 65 degrees—introduces the necessity of placing them for external lighting, at a greater height than that of the open type.

Prof. Elihu Thomson gives the watts per candle as follows:—

Open type	0·70
Alternating open type with reflector ...	0·80
Single enclosed arc...	1·50
Alternating open type without reflector...	1·12
Enclosed alternating	2·0

According to Prof. C. P. Matthews the value of the enclosed arc is 1·46 per mean hemispherical candle power, and its mean spherical candle power 2·08.

NOTES ON ARC LIGHTING.

Fig. 1. Open Type.

Fig. 2. Enclosed Type showing arc wandering.

Fig. 3. Flame Type.

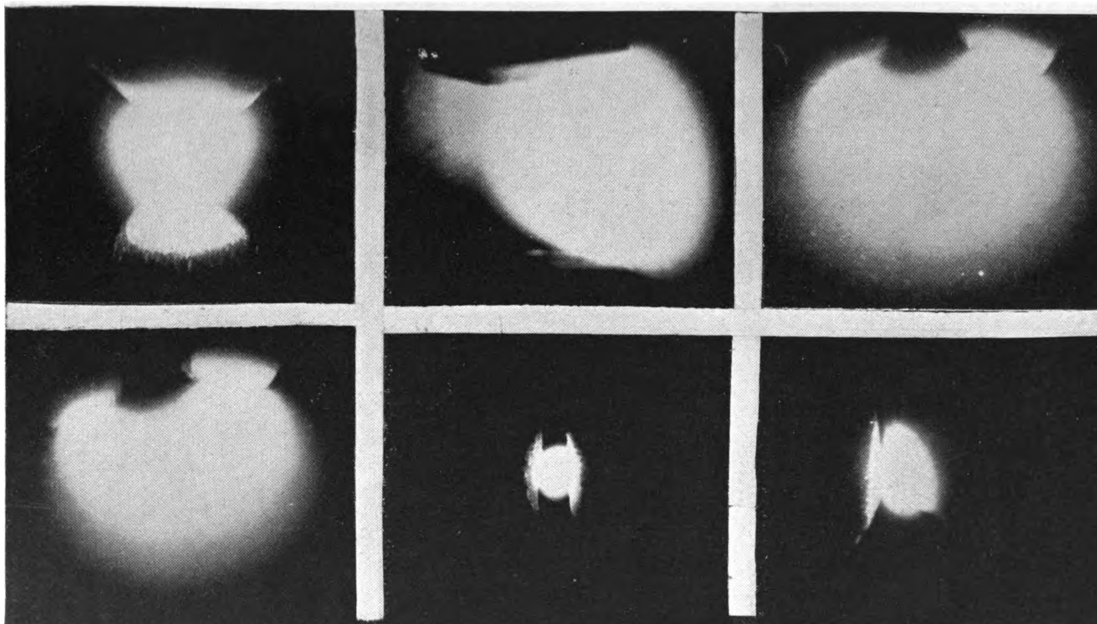


Fig. 4. Flame Type with carbons burning unequally. Positive too fast.

Fig. 5. Flame Type when arc having left core is burning between carbons.

Fig. 6. Flame Type when arc is burning between carbons and consuming metallic deposit.

PLATE 1.

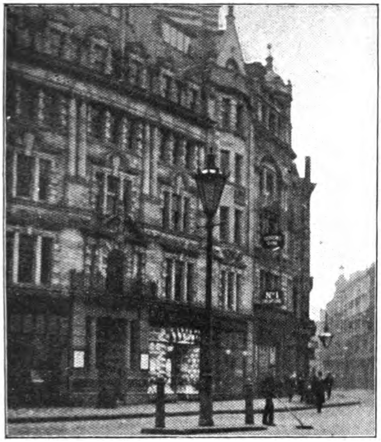


Fig. 7. Brush Double Carbon Open Type.

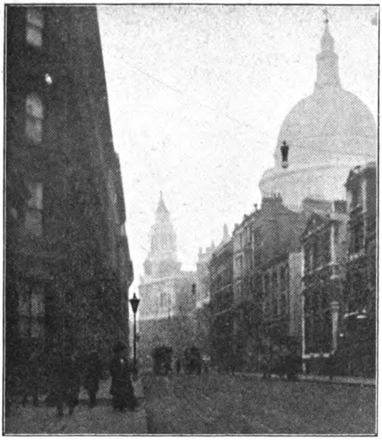


Fig. 8. Oliver Magazine; and Gilbert Multiple Carbon (roadway).

Fig. 9. Oliver Magazine; and Gilbert Multiple Carbon.

Fig. 10. Gilbert 6-pair Carbon Flame.

Fig. 11 Angold Magazine Flame.

Fig. 12. Excello Flame.

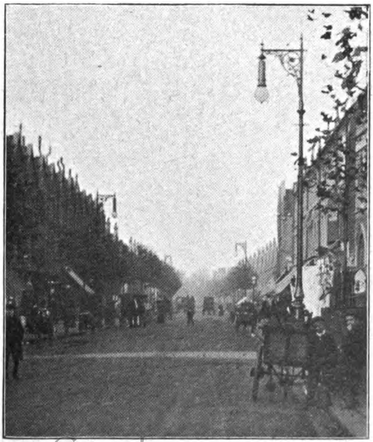


Fig. 13. Angold Double Carbon Open Type.

It will be seen from the above that the mean candle power per watt of the three types of lamps is:—

Enclosed	0·66
Open type	1·42
Flame	4 to 7·0

The placing of the lamp at a greater height in public lighting has the disadvantage that the man in the street does not think he is getting his money's worth, he being accustomed to judge of the power of a light by the irritation it produces, instead of by the reflection from the object to be lighted. In one instance at least, some lamps have been lowered in deference to public opinion, to increase this effect on the ratepayers' eyes. In gas lighting, full advantage is taken of this fact, so that the lights are always kept nearer the ground. Were the lights kept clear of the line of vision, the iris would open wider, and the eye soon accustom itself to what appears at first a poor illumination, with far clearer and better results.

Fechner's law gives the sensation as proportional to the natural logarithm of the stimulus. If the stimulus = 1 c.p., then the sensation produced by 16 c.p. will = log. 16 = 2·77.

Flame lamps.—The credit of bringing the metallic flame lamp forward into the sphere of practicability is undoubtedly due to Bremer, who, in July, 1898, commenced with a series of patents, fifteen in number, and extending over a period of about four years, dealing with the introduction of metallic salts into the cores of carbons and improvements in the construction of the lamps for burning same. They cover, as might be well supposed, a vast amount of research work, and if they do not result in pointing out the path clearly, they at least show what difficulties lie in the way of pioneers.

In connection with the development of the flame lamp the following may be quoted, wherein the inventor claimed, in October, 1899, the use of carbons of angular section for use in a converging type lamp. "Opposite edges of the rods may be notched to cause breaking off of projecting corners, if the arc burns inwards."

Such conditions, however, would of course result in a great fluctuation in the quality and intensity of the light. To-day, even a white flicker is not permissible.

As the early enclosed lamp almost failed because of its excess of violet rays, so the early flame lamp almost failed because of

its excess of yellow, apart from the mechanical defects of the lamp itself. Flame carbons were, however, being used in vertical positions, and were at first made with a core of about $\frac{3}{16}$ inch diameter, within which the metallic oxide was contained. These suffered from the defects of unsteadiness on the one hand, the arc first burning out the core, then running round the carbon edges; while on the other they were apt to deposit the fused oxide on the edge of the positive carbon, so that the lamp was unable to re-start, owing to the insulating properties of the deposit. This latter defect has been one of the main reasons for using converging carbons. Even if the carbons burn away with flat ends, any fused oxide runs to the bottom edges, but the carbons on re-striking will touch together with their upper edges and re-strike.

Need for a two-colour Light Standard.—In comparing different types of lamps, we are in some cases comparing unlike powers of coloured light, by means of the shadows they cast—a most unsatisfactory comparison. For instance, by increasing the voltage across the arc of an enclosed lamp, the current remaining constant, we increase the "light," but we cannot see any better. We may be able to see "worse" in so far that the colours become distorted by the excess of violet. What we require is a standard of quality as well as of quantity, and the only light that can be taken as a standard is obviously daylight.

The luminous rays of the sun consist almost wholly of green and red in the proportion of 2 to 1 (nearly).

A rough approximation to this can be got with strontia and baryta, much employed in the metallic flame arc. The author believes that a better, or at least a more useful result could be obtained by measuring the colours red and green, and expressing them as of so many candle power of those colours, than by the method usually adopted. If the light to be measured be sent through a red screen and compared with that of a standard treated in like manner, the same being done with regard to green, two quantities would be obtained, which, expressed as a ratio, would give a far more useful value for the light than if only its candle power in the ordinary way were known. The nearer the result approached to the ratio 1 to 2, the nearer the light would be to what is required for ordinary lighting purposes.

Discussion.

MR. SIDNEY C. MOUNT, who was asked to explain the construction of the Beck Flame Lamp exhibited to the meeting, said the lamp shown was of the direct current type, consuming 470 watts. The only difference between it and the lamp of the alternating current type was in the arrangement of the pull up magnet. The lamp exhibited burned about 18 hours at one trim, and gave a light output of about 3,500 mean hemispherical candle power. The carbons, inclined, met under a reflector, and the feed was solely by gravity. The negative carbon was furnished with a rib throughout its length, which rested on a copper stop under the reflector, and the arrangement of the lamp was such that this rib supported the carbon of which it formed a part, and by means of a cross connection in the carbon holder it also supported the round positive carbon. Thus as the rib burned away the two descended together without the aid of any mechanism, but simply by the force of gravity. The arc was struck by a series solenoid in the upper part of the lamp, which pulled up when current was switched on, drawing the round carbon away from the ribbed one. When current was cut off the plunger fell and brought the carbons together again. The solenoid and its connecting linkage were the only moving parts in the lamp, and as there was no mechanism to control, there was no need for shunt coils. Probably no arc lamp in ordinary use had so few parts. The extinguishing of the lamp was brought about by the simple device of cutting away a portion of the feeding rib at the upper extremity of the carbon. When this cut away portion arrived at the copper supporting stop, the carbon (which was not fixed in the holder) dropped into an iron receptacle in the lower part of the globe, so breaking the circuit. The ventilation for the flame was introduced through the bottom of the globe, and the fumes escaped round the upper globe ring, special precautions being taken at the burning plate to prevent these having access to the lamp.

MR. A. W. MARSHALL proposed a vote of thanks to the author for his paper and commented upon the importance of the subject. The arc lamp gave a much better return in light for the energy expended than did the incandescent electric lamp. He referred to the occasion as interesting. The Juniors were holding this meeting at the Society of Arts, where, years ago, in the early

days of the electric lighting industry their Past-President, Professor Silvanus Thompson, had lectured upon the same subject. Professor Thompson ingeniously criticised the design of the arc lamps of various countries; Americans made their lamps with few parts and similar in appearance to sewing machine finish; he called them sewing machine lamps; Continental makers favoured escapement movements with trains of light wheels: on that account he called them clockwork lamps; but the English makers made their movements of substantial design with engineering finish, and he therefore called those engineer's lamps. Mr. Marshall believed that there was another lamp besides the "Jandus" referred to in the early part of the paper, made under a separate patent. He was under the impression that good arc lighting was to be obtained with a lower minimum current than seven amperes, as suggested by the author, in fact, with as low a current as three amperes. Could the author say if it was now possible to work alternating current arc lamps in series without a compensating or balancing transformer, which consisted of a coil of wire wound upon an iron core and connected in parallel with the lamps, each lamp being connected to equidistant points along the coil. A coil across the terminals of each lamp was the equivalent of this. He also wished to ask if trouble still occurred with coloured flame arc lamps by reason of noxious fumes emitted from the arc, owing to the combustion of the materials with which the carbons were impregnated. Had the author had any experience of explosions of gas in the globes of totally enclosed arc lamps when the arc was first switched on? The paper contained no reference to an important result incidentally obtained by burning the arc at the underside of both carbons, as with inverted flame lamps. When alternating current was supplied to a lamp which had its carbons placed with their axes in a vertical line the light was thrown alternately in an upward and downward direction, half of it thus being practically lost though the defect could be minimised by means of a reflector. When the carbons were placed side by side and the arc produced at their lower ends however, the whole of the light was thrown in a downward direction. It followed from this that an inverted arc lamp supplied with alternating current at say 25 periods per second, would be equal in lighting effect to a vertical carbon lamp supplied with current at 50 periods

per second. This property made it possible to use arc lamps upon low periodicity power circuits, and might have an influence upon the design of electric distribution schemes which had previously been limited to a minimum frequency of about 45 periods per second.

MR. C. H. SMITH seconded the vote of thanks, and said he fully agreed with the author's views on the utility of the direct-current enclosed arc lamp for the lighting of interiors, which was certainly its particular field of application. The enclosed type of lamp was being extensively used for shop windows, shops, and showrooms, &c. The quality of the light was good, and colours could be readily matched by it. The spherical candle power remained very constant, and no shadows were cast. Such lamps were usually run two in series on 200 to 250 volt circuits, and required a current of about 5 amperes. The twin-carbon enclosed lamp was also extensively used. It had two arcs in series in the one globe, and took a current of from 2½ to 3 amperes, burning singly on 200 to 250 volt circuits. It was useful where only one light was required, such as in lobbies, shop entrances, dark corners of large showrooms, &c., or where separate control over each lamp was advantageous.

The ordinary open-type lamp was useful for outside shop lighting, as the space to be illuminated was comparatively small, and fell within the zone of maximum intensity of the arc, but, as the author rightly said, they could often be well replaced by the flame lamps. These were specially welcomed by the users and suppliers of alternating current. They burned excellently, and would run well in series two on 110 or four on 220 volt alternating current circuits. Even with high frequencies, there was very little "humming." Referring to the author's remarks on the importance of keeping the arc well centred on the carbons, he (Mr. Smith) believed that the cored carbon was first introduced with the object of accomplishing this. The core being of different material and more easily volatilised, kept the arc from wandering. With regard to carbons having a metal wire in the core, if the wires were not arranged centrally, care should be taken in trimming to place the carbons so that the wires were as far apart as they possibly could be, otherwise the carbons would not burn squarely. In regard to inverted arc lamps, there was a fairly wide field of application open to them, particularly in

large commercial offices, drawing offices, and high class drapery establishments. They should preferably be of the open type, with the arc surrounded by a clear glass cylinder, or conical-shaped cover to the bottom basin. The bottom basin could be either of beaten copper, iron, &c., or of opal glass. If the lamps were nicely designed, they had an ornamental appearance, and the illumination was most pleasing and unobtrusive. In some large establishments they were installed almost exclusively for windows (inside) as well as for showrooms, &c. The ceiling could be used as the reflecting agent, or a concentric diffuser could be arranged over the arc. In these lamps the positive carbon was at the bottom.

The author had briefly mentioned magazine lamps, a type of lamp which was rapidly coming into prominence. A number of them had been introduced in the City, and it would be interesting to notice whether they remained there long. They would burn from 40 to 50 hours with one trim, but were somewhat complicated in construction. The "Oliver" flame lamp of the magazine type was made to contain 6 to 10 pairs of carbons and gave a mean hemispherical candle power of 1,200, with 380 watts consumption, or 0·32 watt per mean hemispherical candle power. These lamps would run twelve in series on 460 volt circuits.

The multiple carbon lamp, made by the Gilbert Arc Lamp Company, was of somewhat different construction; the spare carbons, instead of being contained in a magazine and being pushed into place when each preceding one was consumed, were arranged in a row all ready for burning, and the arc jumped from one pair to another at certain intervals. It consumed about 400 watts. and would burn from 42 to 45 hours with one trim. It usually contained six pairs of 16 inch carbons. The mechanism was comparatively simple. An important feature of these lamps was that in them quite an inexpensive class of carbon could be satisfactorily used.

The employment of arc lamps for photographic and other special purposes should not be disregarded. Those taking large currents—up to 80 amperes or so—were hand fed. Multiple carbon lamps were often used, having, in some cases, four arcs in series placed close together. These could be either hand or automatically fed, and took about 15 amperes at 200 to 250

volts. Another very useful form of lamp was made by the Westminster Engineering Company, in which the arc was very long and enclosed in a glass cylinder ; the current taken was from 10 to 15 amperes at 200 to 250 volts.

The author had made no reference to the economic arrangement of arc lamps. The most popular voltages now in use were not very suitable for efficient running. For instance, taking 240 volts as the supply pressure, only two enclosed lamps could be run in series ; the voltage across each being about 90, the efficiency was 75 per cent. Open type and flame lamps could be run with five or sometimes six in series on 240 volts. The voltage across the arc for different makes of flame lamps varied from 35 to 45. If a consumer only required say two open type lamps it would cost him just as much for current to run these two as it would to run five or six on a 240 volt D.C. circuit. Taking the average of several arc lamp installations running on constant potential circuits, the average efficiency for direct current lamps was 70 per cent., and for the alternating current systems nearly 85 per cent. The high efficiency of the latter was due to the use of choking coils or economisers, but they caused an objectional lagging of current. The efficiency of a long series system of course would be higher. A novel idea in shop lighting had just come under the speaker's notice. It tended toward greater efficiency in running, and consisted of a 10 ampere flame lamp arranged in series with two pairs of 5 ampere enclosed lamps, the enclosed lamps being inside the shop and the flame lamp outside. The cost of current was no more than for the two pairs of enclosed lamps alone.

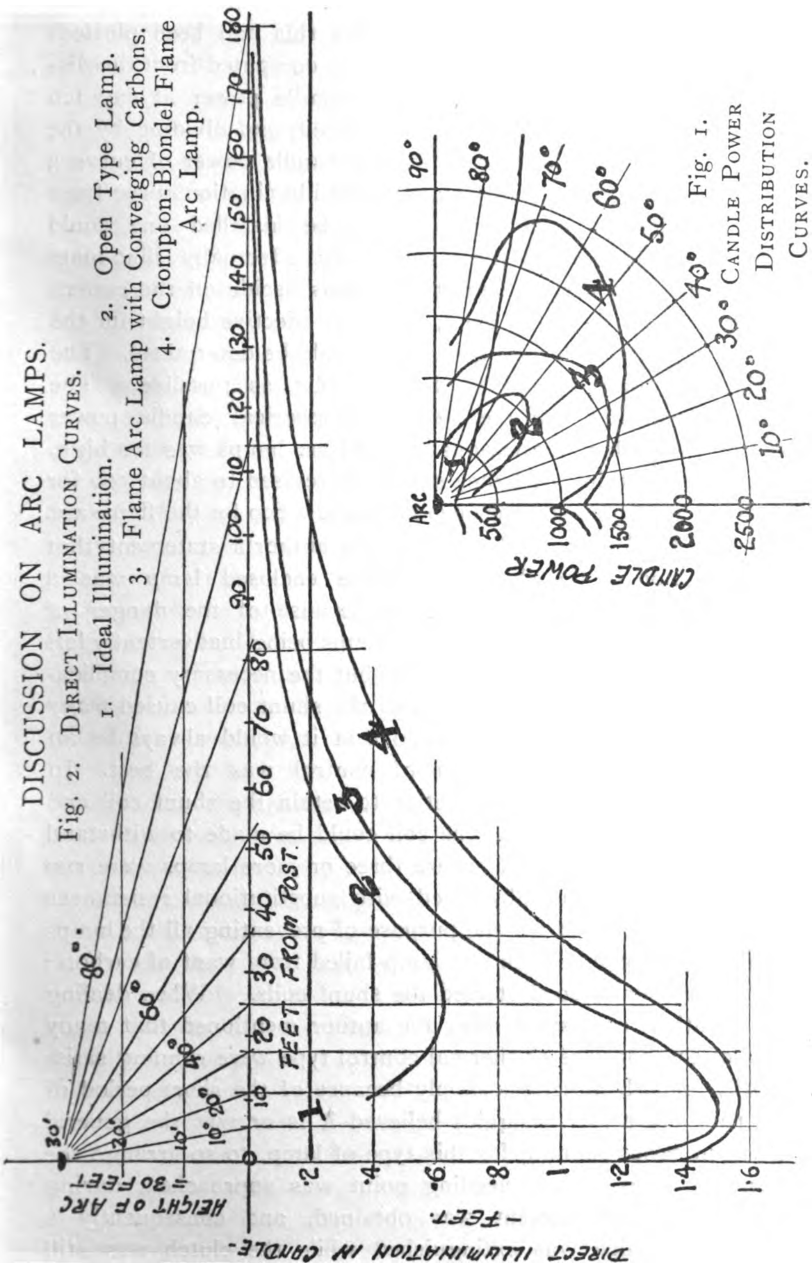
Turning to public lighting, flame lamps were especially useful for that purpose in main and important thoroughfares. To obtain the best results the lamps should be suspended over the middle of the roadway 25 to 35 feet high, and spaced with 45 to 55 lamps per mile. It was interesting to note that the two-lamp standards in Oxford Street, London, were spaced 33 to the mile, thus giving 66 lamps per mile, the height of the arc from the roadway being 26 feet. Circular globes appeared to give the best distribution of light. It should of course be borne in mind that lamps for public lighting must at the time of switching on contain sufficient carbon to carry them through their prescribed run. This provision often necessitated the re-trimming of the

lamps before they were burnt out, and the removal of short but useful lengths of carbon. These could be used up during the short summer nights. If the lamps were trimmed with carbons of different lengths according to the month of the year much of this trouble would be avoided, although the extra cost of the special carbons might possibly be found prohibitive. There was always a certain percentage of waste in the use of carbons, and the useful length could be taken as 75 per cent. to 80 per cent. of the total.

The total cost per lamp hour for an installation of 90 flame arcs of the ordinary converging carbon type was 1·578 penny, as shown by the following:—

	Penny.
Carbons at 42s. per 500 feet (250 feet pos. and 250 feet neg.)	0·262
Current at 2d. per unit (500 watt lamps) ...	1·000
Wages for trimming and repairs	0·300
Sundry materials	0·016
	1·578

The candle power distribution curve of the arc lamp, that was, the candle power at any angle with the horizontal in a vertical plane through the arc, was far from the ideal for street or open space lighting purposes. To give a uniform illumination over the street the candle power at any angle would have to be proportional to the square of the distance through which the light had to travel before reaching any point on the ground or a plane parallel with it. Referring to the diagrams, in Fig. 1 were plotted the candle power distribution curves of four kinds of arc lamps, viz.: (1) a lamp giving an ideal distribution curve; (2) an open type lamp; (3) flame arc lamp with converging carbons, and (4) Crompton-Blondel lamp, with carbons arranged vertically (positive at bottom). Fig. 2 was plotted from the distribution curves by dividing the candle power at any angle by the square of the distance from the arc to the point of incidence with the ground or any other parallel plane on which the illumination was to be considered. Thus $I = \frac{c\,\rho}{h^2 \times D^2}$ I being the illumination in candle feet, h the height of arc from plane, D the horizontal distance from a point immediately below the arc.



DISCUSSION ON ARC LAMPS.

Fig. 2. DIRECT ILLUMINATION CURVES.

1. Ideal Illumination.
2. Open Type Lamp.
3. Flame Arc Lamp with Converging Carbons.
4. Crompton-Blondel Flame Arc Lamp.

Fig. 1. CANDLE POWER DISTRIBUTION CURVES.

Assuming 0·2 candle feet as a good uniform illumination, the ideal distribution curve that would give this had been plotted. The mean hemispherical candle power was computed from the distribution curve by simply adding the candle power at say ten equidistant points (as on the angles marked) and dividing by the number. Thus the mean hemispherical candle power of curve 3 was 1,305 candle power. By plotting the illumination curve from the distribution curve of the lamps to be installed one could arrive at the area which the lamp would effectually illuminate when placed at a certain height, and thus decide on the correct spacing; or, on the other hand, the most effective height for the lamp to be placed to light a given area could be determined. The illumination curve should be kept as flat as possible. The speaker considered that the mean hemispherical candle power given by the author, for various types of arc lamps was too high. He ventured to think that they should be revised to about 500 for the enclosed type; 800 for the open type, and 1,600 for the flame arc.

MR. H. E. ANGOLD, referring to the author's statement that the elimination of the shunt coil in the enclosed lamp was a distinct step in the right direction because of the danger of destruction of such coils through the lamps being inadvertently left on open circuit, said it might be so, but the necessary complications attendant on the elimination of the shunt coil caused many counterbalancing disadvantages, so that it would always be an open question as to which form of control was the best. In the speaker's opinion it was better to retain the shunt coil and the simple feeding gear, as the coil could be made to withstand 250 volts if necessary, and where three or more lamps were run in series they were usually fitted with substitutional resistances and automatic cut-out for the purpose of preventing all the lamps in a series going out when one lamp failed from want of carbon; this arrangement also protected the shunt coils. When dealing with shuntless enclosed lamps, the author mentioned that many lamps of the hot wire or thermal control type were running satisfactorily enough in series, simply because of the short period of each run. He (Mr. Angold) believed it is or was the general method in series running for this type of lamp, to so arrange the expanding strip that as feeding point was approached, during burning, a lower current was obtained, and consequently a longer arc, which was extinguished while the clutch was still

gripping the carbon. The strip then contracted, setting the clutches free and allowing the carbons to come together and restrike. All the arcs in series were of course affected, restriking being simultaneous. Owing, however, to the sluggishness already mentioned, the arcs remained out for some time while the strip was cooling. Perhaps the most trying condition for this type of lamp was when running in connection with a traction circuit, where the sudden drop in voltage due to the starting of a train extinguished the arcs, which, remaining out for some time, caused frequent periods of complete darkness. In describing one restriking arrangement for a magnet or solenoid control lamp without shunt coil, in which the core was divided, the upper part being arrested at a certain position, the author said that the core separated and caused a weakening of the field and consequent falling of the lower part of the core, which in turn, allowed the carbons to come together and restrike. He (Mr. Angold) believed, however, that the actual effect would be to hang up the whole core, since the two parts would be held together so long as there was a fair amount of magnetism. The arcs would then go out, and the current being cut off the solenoid the lower part of the core would drop in all the lamps in the series, and cause restriking. The same principle, restriking the arcs, had to be employed in the twin arc lamp, as it was impossible to ensure that two carbons would feed at exactly the same moment and exactly the same amount.

Regarding the uneven burning of flame carbons, he had found from experience that there was a tendency for the carbons to equalise within certain limits, *i.e.* if one carbon was lower than the other it would burn slightly faster until they were both even. With both carbons having metallic oxides cores, these limits were wider than with a plain core carbon for the negative, each carbon evidently supplying a certain amount of oxide to the arc in accordance with the position of the carbons; if the negative were lower it supplied proportionately more oxide to the arc until the carbons were equal. With a plain cored carbon for the negative, however, the arc was fed from the positive core only, and the ratio of consumption of each could not vary very considerably. In the latter case, however, the arc was much steadier, as it did not seem to travel round the negative carbon like it did at times when both the carbons had metallic oxide cores.

MR. M. H. HANKIN, commenting on the author's remarks as to the need for a two-colour standard of light, said the measure of the candle power of two colours only, would be no measure of the usefulness of the light. For instance, it was possible to see by the mercury vapour lamp, but if it were tested in the manner proposed, its candle power would be practically nil. The latest form of Flicker disc enabled the comparison of different coloured lights to be determined easily and accurately. It consisted of a revolving disc, which enabled the lighting effect of two sources of light to be seen one after the other in rapid alternations; when the lights were unequal a flickering was observed, which ceased entirely when they were equalised. He failed to see the necessity for the standard of light suggested, as there was a definite proportion of red and green rays in the 10-candle pentane lamp, which was a recognised standard of light.

MR. C. G. EVANS asked the author how the results obtained by his method of colour testing could be appreciated in terms of ordinary illuminating effects, and whether it was possible to compare illuminating values on a basis of cost per candle; whether he was in favour of still continuing the customary 10-candle power Harcourt or Incandescent lamp; and what his reason was for considering that the light emitted by an incandescent gas mantle was not perfect in quality.

MR. BERNARD BROOKS asked if the author could give some comparative figures of the cost of running flame arc lamps, enclosed type lamps, and those of the open type, the cost of current being the same in each case, but taking into consideration the cost of repairs, carbons, and re-trimming over a given number of hours, say 1,000 hours, the basis of comparison being the equal illumination of a given area. He also enquired whether the author knew of the existence of a flame lamp named the "Simplex," in which the feed of the carbons was by gravity, exactly in the manner described by Mr. Mount when referring to the Beck lamp. Was such an arrangement for feeding likely to prove satisfactory in practice?

MR. F. D. NAPIER could not agree with the author's apparent approval of hot wire control, at any rate for direct current circuits. In a fairly large installation by a firm considered to be the leading exponents of that type of arc lamp, the experience had been anything but satisfactory, as the lamps did not seem

to work well in series, and further, caused considerable local disturbances in the supply pressure. This might of course be due to the particular lamp, but still the fact remained. A lamp not mentioned by the author and deserving of notice, was the Crompton-Blondel Flame Arc, which was particularly well adapted for street lighting, as the distribution of light was very good. The carbons were vertical, the lower one being positive and of greater diameter than the negative. The quality of light given was a mean between that from an ordinary open white arc and the orange coloured light given by most of the inclined flame arcs. The lamp was of British manufacture, so there was now no need to buy a lamp made out of this country. Some very recent tests conducted with a view of deciding which lamp to adopt for the public lighting of a London suburb had proved the British lamp superior to any of the foreign lamps submitted for trial.

MR. W. HOGG, referring to the author's comments on the ratepayers' objection to the great height of the arc lamp in public lighting, said it appeared to him that these long suffering people wished to have their "money's worth" distributed nearer to the road surface, rather than on the tops of their houses. As the author apparently regarded the ratepayers' complaint as unjustifiable, or "public opinion" wrong, would he in his reply say whether he thought there was any possibility in the near future of the arc lamp competing with incandescent gas for public lighting, on a basis of cost per unit of light?

MR. A. H. STANLEY remarked that though the author regarded light tests as unimportant unless they included comparisons of colour, yet the practice still continued of testing the relative efficiency of lamps by comparing their relative candle power per watt consumption. Some striking results of such tests, not commented upon by previous speakers, were given in the paper, showing that the mean candle power of the enclosed type, viz., the type which the author said "will hold the field for many years to come," was by far the lowest of all three types, being only 0·66 per watt, compared with 4·0 to 7·0 mean candle power in the flame type. Thus the flame lamp, judged by the usual light test, was seemingly from 7 to 11 times as efficient as an enclosed lamp, and its only serious drawback was the formation of oxides, as pointed out by the author. But even this difficulty

would no doubt be overcome in course of time by the genius of some inventor who refused to be discouraged by past failure. It was somewhat regrettable that the credit of introducing a workable flame lamp did not rest with a British subject, but some consolation was to be found in the reflection that the British Patent Law had heretofore enabled foreigners who held patents, to prevent certain industries from being carried on in the United Kingdom, whilst the British demand was being met by importations from the Continent. The time-honoured saw that the "law is a hass" would be less true of English Patent Law after January 1st, 1908, on which date the new Act would begin to run. One effect of it would be to render a patent invalid if the patented article or process was manufactured or carried on exclusively or mainly outside the United Kingdom.

MR. R. H. PARSONS hoped that the author in his reply would deal with the question of running flame arc lamps in series on alternating circuits. The fact that an alternating current flame arc had as high an efficiency as a continuous current flame arc made the problem of great importance, and it was worth a great effort to find a satisfactory solution. Many makers denied that difficulties existed, at least if their particular lamps were used, but the speaker knew of a case in which a considerable order depended upon a satisfactory result being demonstrated. The supply in that case was at 400 volts, 50 cycles, and it was required to run a reasonable number of lamps in series across the mains. The makers expressed their confidence at first in running, he believed, ten lamps in series, but, like the ten little nigger boys in the story, this number was gradually reduced to vanishing point. The employment of transformers or choking coils for every street lamp was out of the question, so the town had to do without general flame arc lighting. Could the author indicate wherein the difficulty lay, and what features should be embodied in the lamps to mitigate it? The question of fumes given off by flame arcs had been mentioned, but the incandescent gas mantle was probably equally deleterious to health in a closed room. A severe headache after testing or experimenting with flame arcs was no proof of poisonous fumes, for the same symptom was liable to occur after working with any other excessively strong light.

THE CHAIRMAN, in closing the discussion, said he felt that the

Institution had had an interesting and valuable paper from Mr. Krause, and expressed the opinion that the whole matter of street lighting required thorough re-organisation. He thought it curious that, with the improvement of the illuminating power of gas by means of the incandescent mantle, and with electric lighting by means of arc lamps and incandescent glow lamps, that very little attention appeared to have been given to the question of the most advantageous height at which these lamps should be placed in the street. In the majority of cases the old cast-iron standards of the batswing burners were being used to these improvements. Surely if the height for the batswing burner was correct, the same height could not be correct for the high powered illuminating burners or electric light. He then called attention to the lighting of Oxford Street, which he thought was obviously a most uneconomical arrangement, as at least from one-third to one-half of the illuminating zone of twin flame arc lamps as hung in that street was simply wasted by overlapping.

The vote of thanks having been carried by acclamation,

MR. WILLIAM KRAUSE expressed his acknowledgments, and proceeded to reply to the various points raised in the course of the discussion. As time did not permit of his replying verbally to all, he has sent a written statement which has been incorporated in the following :—

Replying to Mr. A. W. Marshall, the author said he was not aware of any enclosed lamp other than the "Jandus"—or those licensed by the patentees at the time mentioned—although there were many "patent" enclosed lamps on the market, the patents relating only to the controlling mechanism. The current limit given in the paper for good lighting results referred only to open type lamps. A current of three amperes was being used in hundreds of enclosed lamps with satisfactory results, but such a low limit was rejected years ago for the open type, although re-introduced by several Continental makers. Alternating current lamps were still being run with a balancing coil, and there appeared no possibility of running them in series without, owing to the distributing effects of phase distortion caused by each varying arc. The balancing core, or the connecting across of an inductive circuit described by Mr. Marshall, was, however, not without its advantages from the consumers' point of view, in so far as it permitted each lamp to be used separately at an additional cost of

only that of the magnetising current of the coils across the lamps not in use. Substituting a resistance for a lamp in the direct current was of course no saving at all. The explosion often observed in the globe of an enclosed lamp, when switched on a few minutes after the lamp had been off, was due to the products of combustion of the carbons cooling, causing an in-rush of air, and forming in combination with the CO, an explosive mixture, which was ignited on re-striking the arc, resulting in the explosion referred to. With a well-constructed alternating current enclosed lamp, having the carbons vertical in the usual manner, it was not correct to say that half the light was wasted; the nature of the metallic deposit on the cap of the enclosing globe was such as to reflect at least 60 per cent. of the light emitted by the bottom, so that the total loss was nearer one-fifth than one-half. If the carbons were set converging as suggested, so as to emit the whole of the light of their craters downwards, the increased efficiency would be 20 per cent., and the periodicity could, as stated, be reduced by one-half, and still have the same optical effect, but while making the lamp to take the converging carbons, why not use metallic flame carbons at once, unless the lamps were required for indoor use? In that case he (the author) feared, from experience, that the open type would have to be abandoned, and the enclosing of the arc would make the control difficult.

Mr. C. H. Smith, in referring to the "Gilbert Multiple Carbon Lamp," led one to infer that the using of a comparatively cheaper carbon was the especial feature of that lamp, whereas the carbons employed in it were only less expensive because of there being no metal wire in the cores. This, however, necessitated shorter carbons, because of the greater resistance, and consequently resulted in a life of from four to six hours per carbon. Here then followed the magazine lamp, which replaced those short carbons by others, as in the "Oliver" or the one exhibited to the meeting—the "Angold." With the "magazine" type of lamp there was the advantage also that the lamp could be fully trimmed by simply filling the magazines; a pair of half burned carbons was left in *in situ*, and nothing was wasted, except the stumps, pushed out of the contacts. Regarding the number of lamps per mile given by Mr. Smith for public lighting, the author believed that it was more usually determined by the cost of the installation than by the best results to be obtained by any given

type of lamp. In general, he had found the distance between lamps to be about 150 feet. Referring to the value given in the paper for the mean hemispherical candle power per watt of the arc of different types of lamps, the author saw no reason for departing from those values, and would point out that those given by Mr. Smith were for total watts in lamp and resistance, and were very near those given by Prof. Thomson and Prof. Matthews; whereas those given by the author were for the arc only.

Replying to Mr. Angold, the author felt quite content to leave the question of the shuntless lamp to the future, although he fully recognised the value of the remarks made regarding certain complications due to the elimination of the shunt coil. There were, however, at present a large number of shuntless lamps in use, and he supposed every engineer would retain his own opinion, and await the results of experience. In referring to some hot wire lamps as running steadily simply because of the short duration of the run, he (the author) did not wish to convey the meaning that the lamps were fed solely by this, but rather to show how lamps, although tending to burn more and more unevenly, due to the clutch slipping, were brought again to a state of satisfactory burning by the re-starting of the lamp, and that this idea was utilised in the shuntless lamp. Mr. Angold referred to the plain cored negative as giving the steadier arc. There was, however, the objection to it, that when running with low arc voltages, the arc was more apt to leave the positive core, owing to the negative becoming coated with deposit, when the colour of the arc changed completely. With both carbons cored, however, even if the arc left one of the cores, it at least retained its flame colour.

The illustration of the mercury vapour lamp referred to by Mr. M. H. Hankin was an excellent one wherewith to show the need of a minimum two-colour standard. The awful spectre-like effect caused by that lamp could only be fully realised by being in a room "lighted" by one of them. Many had been the attempts to colour the light, but until sufficient red and green had been introduced, equal to that in the pentane lamp for example, light could never be satisfactorily measured. The light from a ruby lamp could also be measured by the pentane lamp just as Mr. Hankin considered should be done with that from the mercury vapour

lamp; but the comparison would not be satisfactory, because of the fact that we are able to discern objects, but we cannot be said to "see."

In reply to Mr. C. G. Evans, the author pointed out that with the standards already established it would be a fairly easy matter to compare the illuminating values on the ordinary basis of cost per candle. As to the author's reason for considering that the light emitted by an incandescent gas lamp was not perfect in quality, he could but reiterate what he had stated in the paper that until a light was equal in quality to sunlight, it was imperfect.

With reference to the question raised by Mr. Bernard Brooks regarding the cost of running flame lamps, he believed that future results would be in favour of the magazine type of flame lamp, but it was too early at present to get anything like useful comparative costs of running.

He hoped he had not led Mr. Napier to think that he preferred the hot wire lamp; he had merely described the method as one, that, at least with the alternating current, gave a fairly satisfactory result; he was quite aware of its heavy starting current. The introduction of the hot wire had had the effect of considerably cheapening the cost of the enclosed lamp, and it was, he thought, by the introduction of the shuntless lamp, but with the magnetic control, that the starting current could be lightened at approximately the same cost as that of the hot wire lamp.

Replying to Mr. W. Hogg, he wished to say that it was immaterial whether the light emitted from the lamp at right angles to the direction of the street illuminated the tops of the houses or only the walls. The placing of the lamps at a greater height was more in accordance with the natural condition of the light descending from above. With reference to the question of the arc lamp competing with incandescent gas for public lighting, he had at the present time a contract in hand which would displace some scores of incandescent gas lamps in a London suburb; the price of the arc system comparing very favourably with that of incandescent gas.

Mr. A. H. Stanley had correctly stated that the candle power per watt of the enclosed type of lamp was the lowest of any given, but it was also stated in the paper that, compared with the open type, the enclosed was more efficient as regards its use-

value, by reason of its better diffusion. Compared with the flame lamp for outside lighting it was of course entirely eclipsed.

The operation of the new Patent Law referred to by Mr. Stanley, would no doubt be watched with considerable interest by those engaged in the arc lamp business.

In reply to the interesting question raised by Mr. R. H. Parsons—that of running alternating current flame lamps in series without the use of balancing coils, the author was not aware of any method to ensure proper working under such conditions. He believed that the peculiar current surging effects noticed in the early attempts with the open type would be present in the flame lamps, although not to such a great extent. He doubted, however, the wisdom of dispensing too readily with the employment of balancing coils, as he knew of one large municipality that had decided on small auto transformers, the cost of which did not affect the total cost of installation.

Regarding the Chairman's remarks concerning the twin lighting of Oxford Street, he quite agreed that the method of lighting there adopted was uneconomical. A much better result would be obtained by spacing the lamps out singly equidistant from one another, 30 feet from the ground, but staggered, so as to cause a softening of the shadows.

Correspondence on Mr. Krause's Paper.

MR. E. J. WATKINS writes:—The author has raised many interesting questions in his paper, but from the point of view of future advance in our methods of public lighting, perhaps one of the most important observations is to be found in his condemnation of the system of hanging lamps too near the ground. That "the power of a light is judged by the irritation it produces," doubtless correctly sums up the attitude of the great British public towards street lighting generally, but this hardly justifies the engineer in perpetuating an obviously faulty and inefficient system of distributing light. In the lighting of large works, railway sidings, &c., due regard is paid to efficient dispersion of the light by means of high lights, and it is only in the public streets that the acme of lighting seems to be best expressed in the word "glare." In many streets quite a short exposure

results in dazing of the eyes and consequent strain upon the nervous system. This may not really be due so much to the quantity of light as to the qualitative composition, *i.e.* its content of rays having a different wave length to those for which the retinal nerves are normally attuned. According to the theory of Helmholtz, fatigue is produced as the result of a too pronounced excitation of the specific colour, nerve endings, one result of which is that the colour sense recorded on the brain is the complement of the colour which produces it. The present idea of some methods of public lighting, particularly business premises, appears to be aimed at creating as much nerve irritation as possible, the commonest forms of the evil consisting in the use of gross excesses of blue or yellow rays. As a consequence, seeing is not better, but owing to the irrational colours under which the objects are viewed, it is frequently decidedly worse, and perhaps the only practical result obtained, is that defective work and inferior goods are often obscured and rendered more difficult to detect. No one for instance, would dream of viewing Rembrandt's "Night Watch" under the full rays of an arc lamp, for the simple reason that the delicate shadows and reflections upon which the whole artistic effect depends would be obliterated by such treatment, whilst the colour scheme would be irretrievably spoiled. In the arc lamp lies the possibility, if anywhere, for obtaining an approximation to the ideal, viz., diffused sunlight. Now this sunlight is the resultant, emitted by a huge number of bodies in a state of incandescence. Up to the present the attempts to imitate this light have been limited to one or two, or at most a very limited number of bodies used in admixture. Such methods can only give us a resultant compounded of very limited portions of the visible spectrum, and it seems highly probable that we must largely extend the number and also carefully adjust the relative quantities of the substances employed before reasonably good results are obtained in this direction.

In this connection the author's proposal to measure the power of a light in terms of its constituent colours appears to be a step in the right direction. The suggested limitation of the test to a simple measurement in terms of red and green is no doubt intended simply as a measure of "practical politics," for it can hardly be considered likely that the method once adopted would be limited to those portions of the spectrum per-

manently. In this work it would seem that there is a good possibility of utilising the tintometer, provided a suitable set of standard tint glasses were devised. It is much to be desired that the author will be able to carry his proposal to a successful conclusion.

MEETING OF MEMBERS AT BIRMINGHAM.

The second meeting of the Birmingham members and their friends took place on Tuesday, 10th December, 1907, at the headquarters of the Birmingham Detachment of the Electrical Engineers (R.E.) Volunteers, John Bright Street, by kind permission of Lieut. J. F. Lister, E.E. Vols.

Mr. E. A. Dowson (Member) presided, the attendance being four members and five visitors.

Owing to the indisposition of Mr. R. B. A. Ellis, the paper ("Notes on Arc Lighting," by Mr. William Krause) was read by Mr. Boggust.

A short discussion ensued, opened by Mr. H. T. Poole, who proposed a vote of thanks to the author for his paper, which was seconded by Mr. Luyks. The discussion had reference principally to the question of gas versus electricity, which at the present time is receiving considerable attention in Birmingham, both undertakings being owned by the Corporation.

The proposed rules for the formation of local branches of the Institution, as drafted by the Council, were also read and explained by Mr. Ellis.

The proceedings closed with votes of thanks to Mr. Boggust for reading the paper, and to Lieut. Lister for the use of the meeting room.

Part 5. **FEBRUARY, 1908.** **Vol. XVIII.**

The Junior Institution of Engineers

(Incorporated).

President - - M. GUSTAVE CANET.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

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Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

30th January, 1908.

ANNOUNCEMENTS.

FRIDAY, 7th February, at 8 p.m. **An Extra Meeting will be held at The Royal United Service Institution, Whitehall,** when a paper on "**Aerial Navigation,**" by MR. HERBERT CHATLEY, B.SC.ENG., will be read and discussed. The President, **M. Gustave Canet,** will take the chair at this meeting, and some of the well-known French and British workers on the problem of aerial flight are expected to be present to assist in the discussion.

SATURDAY, 8th February, at 6.30 for 7 p.m. Anniversary Dinner at the **Hotel Cecil, Strand,** the President in the Chair.

WEDNESDAY, 12th February, 7.30 p.m. Joint Meeting with the Discussion Section of the Architectural Association at **12 Tufton Street, Westminster.** A paper entitled "**Suggestions as to how the Architect and Engineer can combine,**" by MR. PERCY J. WALDRAM, F.S.I. (*Past-Chairman, J.I.E.*), will be read and discussed.

THURSDAY, 20th February. Meeting at 8 p.m. at the **Royal United Service Institution, Whitehall,** when a paper entitled "**Practical Notes on the Testing of Gas Engines,**" by MR. GILBERT WHALLEY (*Member of Council*), will be read and discussed.

SATURDAY, 22nd February, at 3 p.m. Visit to King's College, Strand, for inspection of **Experimental Apparatus, &c.,**

to be shown by Professor D. S. Capper, M.A., M.Inst.C.E. (*Hon. Member*) (Civil and Mechanical Engineering), Professor Ernest Wilson, M.I.E.E. (Electrical Engineering); and Professor H. Wilson, F.R.S. (Natural and Experimental Philosophy).

In order that proper arrangements may be made to enable every Member to see the whole contents of the three departments, it is necessary that those intending to be present should give their names to the Secretary **not later than Wednesday, 19th February.**

FRIDAY, 13th March. **Meeting at 8 p.m.** at the **Royal United Service Institution, Whitehall.** A paper on "**The Purification of Water,**" by MR. GEO. H. HUGHES, M.I.Mech.E. (*District Member of Council, Eastern Counties*), will be read and discussed.

SATURDAY, 21st March, at 7 p.m. Reception at the **Caxton Hall, Westminster (Conversazione, Dance, Concert and Whist Drive).**

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

BRAY, HERBERT PAINE; Motor Department, London General Omnibus Company, Dollis Hill, Cricklewood, N.W.

GOODMAN, WILLIAM HENRY; Messrs. Thwaites Brothers, 96 Leadenhall Street, London, E.C.

JONES, HENRY O.; Messrs. Archibald Dawnay and Sons, Battersea, S.W.

KUPFERBERG, BERNARD ADALBERT; 253 Vauxhall Bridge Road, London, S.W.

LOISU, POLYBIUS; 3 Pitman Street, Cardiff.

Proposed for election to the class of "Associate."

HUMPHREYS, HENRY; Metropolitan Railway Company's Works, Neasden, N.W.

JEPHSON, PHILIP HENRY REISS; Engineering Department, The University, Cambridge.

PERSONAL NOTES.

H. G. Crabb has been engaged as Technical Representative of "The Electrical Review" in connection with the publications, &c., of Messrs. Alabaster, Gatehouse and Co.

J. H. Drew has been appointed Engineer and Surveyor to the Horbury Urban District Council.

A. W. Ellson Fawkes wrote from London, Ontario, under date 4th January, on the exceptionally bad state of general trade in Canada and consequent depression in engineering circles. There were, however, indications of a revival, but some months must elapse before business recovered its former vitality.

F. J. G. Graham (Chiromo, British Nyassaland) expects to be home in July next.

J. Henderson sailed on the 8th January for British Guiana, to take up an appointment under the Guiana Gold Company. Address, The Guiana Gold Company, Konwaruk River, British Guiana.

A. Cecil Kent, previously with the White Steam Car Co. at Edinburgh, is now engaged on experimental work in the steam car department of the S.M. Car Syndicate, 9A Hythe Road, Willesden Junction, N.W.

Sidney D. Lancaster is now engaged with Messrs. Hunter and English, Ltd., Engineers and Millwrights, Bow, as General Manager and Director.

Wilfred J. Matthews, of s.s. "Indraghiri," will be in port at Glasgow till 15th February, during the overhauling of his ship. Address, c/o Messrs. Rowan and Co., Engineers, Glasgow.

Wallace McMullen is temporarily engaged at Coolcan, Dunneedaw, Rangoon, Burmah.

W. J. Pendleton, writing from Jubaland, British East Africa, on 18th December last, referred to the improving industrial prospects there. Cotton growing, which had been started on the Italian side of the Juba river (Italian Somaliland) was likely to be greatly developed during the present year.

G. Penn-Simpkins has been transferred from the State Railway Branch, to the General or Roads and Buildings Branch of the Public Works Department, and has been posted to the newly created Province of Eastern Bengal and Assam as Executive Engineer, Decca Division, and Inspector of Local Works. Address, Executive Engineer, Decca Division, Decca, Eastern Bengal, India.

H. H. Thorne has been appointed Chief of Drawing Office of Messrs. David Brown and Sons, Park Gear Works, Lockwood, Huddersfield.

Edward Underwood has commenced practice as Architect and Surveyor, in partnership with Mr. Philip Kent, at 19 Leys Avenue, Letchworth, Herts.

Appointments.

109. An engineer about 30 years of age, who has had a thorough practical training in marine engineering work is wanted as teacher at a college for naval engineers in South America. Salary £420 per annum; agreement by arrangement. First class passage out and home.

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217. Member, age 26, Assoc.M.Inst.C.E., desires responsible position on work's staff, preferably as Manager's Assistant. Eight years' experience in all branches of manufacture and design of structural steel, bridge and roof work.

218. Member, age 34, desires appointment at home or abroad. Fifteen years' experience in Mechanical and Electrical Engineering. Thorough knowledge of alternating and continuous current work. Speaks French and is acquainted with the Continent.

219. Member, age 30, is open to engagement. Motor designer and engineer. Speciality—design and construction of heavy oil engines for marine or agricultural traction work.

Changes of Address.

BOULT, ERIC, 3 Ormond Road, Richmond, Surrey.
DINSLEY, A. R., Messrs. John Holroyd and Co., Milnrow, Rochdale.
DEWYNTER, G. F., 34 Derby Road, Ponders End, Enfield, N.
FULLER, W., Vanbrugh Cottage, Maze Hill, S.E.
HALL, A. G., via y Obras, Estacion Ouca, F.C.O., Buenos Ayres.
KENT, A. CECIL, 35 Larden Road, Acton, W.
NOWLAN, H. J., 157 Lower Road, Southwark Park, S.E.
REID, H. CARTWRIGHT (*temporary*), Hotel Pension des Alpes, Baumaroche, Mont Pelerin, sur Vevey, Switzerland.
ROSS, J. W. G., "Silverdale," Babington Road, Streatham, S.W.
WATKINS, H. S., "Claremont," 23 Lonsdale Road, Barnes, S.W.

Library.

Since the last announcement the following have been presented to the Library:—

Boiler, The Practical Physics of the Steam, by Frank J. Rowan, A.M.I.C.E.; from Mr. F. R. Durham (*Chairman*).

Concrete-Steel Building, by W. Noble Twelvetrees, M.I.Mech.E.; from Mr. F. R. Durham (*Chairman*).

Civil Engineers, Institution of, Part 3, Volume CLXIX., Minutes of Proceedings; from the Institution.

Electric Transmission of Power, by Alton D. Adams; from Mr. F. R. Durham (*Chairman*).

Fire Extinguishers, Fire Tests with, Report No. 124; from The British Fire Prevention Committee.

Floors, Load Test of, Report No. 125 of the British Fire Prevention Committee; from the Committee.

Foundry Practice, Modern, by John Sharp, Wh.Sc.; from Mr. F. R. Durham (*Chairman*).

Hydraulics, A Treatise on, by W. Cawthorne Unwin, LL.D.; from the Author (*Past-President*).

Master Car Builders' Association, Volume XLI., 1907 Proceedings; from the Association.

Mechanical Engineers, Institution of, Parts 1 and 2, 1907 Proceedings; from the Institution.

Motors, Internal Combustion, The Limits of Thermal Efficiency in, by Dugald Clerk, M.Inst.C.E.; from the Author (*Past-President*).

Patents Act, 1907, The (*Pamphlet*), by John E. Raworth; from the Author (*Member*).

Patents and Designs Act, 1907, by J. Roberts and H. Fletcher Moulton; from Lord Justice J. Fletcher Moulton (*Past-President*).

Producer Gas, by J. Emerson Dowson, M.Inst.C.E., and A. T. Larter, B.Sc.; from Mr. F. R. Durham (*Chairman*).

Spons' Engineers' and Contractors' Diary and Year Book, 1908; from the Publishers, Messrs. E. and F. N. Spon.

Warming Buildings by Hot Water, by F. Dye, M.R.I.; from Mr. F. R. Durham (*Chairman*).

Western Australia, Geological Survey, Bulletin No. 26, Miscellaneous Reports, Nos. 1-8; from the Agent General.

Waterworks Engineering, Principles of, by J. H. T. Tudsbery, D.Sc., and A. W. Brightmore, D.Sc.; from Mr. F. R. Durham (*Chairman*).

CHAS. H. SMITH,
Hon. Librarian.

CORRESPONDENCE.

BRIDGE ERECTION AT CHIROMO, B.C.A.

FRANK J. G. GRAHAM (Shire Highlands Railway, British Central Africa), in a letter from Chiromo, British Nyassaland, dated 10th December, 1907, referred to the busy time he had been having, the erection of the screw bridge at Chiromo, situated about 250 miles from the coast, having been commenced. The gear available was of a poor description, all hand-worked, and labour very scarce. The natives who could be secured worked with little energy, and there had also unfortunately been sickness amongst the staff. Rough timber was being used for the job throughout, none being imported. The bridge consisted of four spans of 45 feet, and one lifting span of 112 feet, standing on clusters of screw cylinders. The erecting timbering was not yet finished, and the river was up 5 feet, so that work in the river bed had to be stopped until the water subsided. There were no lighters or barges available as they were now all required for ordinary transport purposes.

FROM THE STARTING PLATFORM.

FERRO-CONCRETE. The last two years have witnessed a great advance in this country in the use of ferro-concrete for all classes of engineering and building construction, especially the latter. The first prejudices against it seem to be passing away, and those who only a comparatively short time ago had doubtful misgivings as to its advantages may now be said to be in its favour. That such misgivings should have existed was only reasonable when it is remembered that questions of the effect of the combination of two entirely different materials—concrete and steel—were involved. But these questions are now largely, if not altogether, disposed of, and the engineer or architect as the case may be, may safely adopt this method of construction, provided the materials are satisfactory, and are properly put together.

On the Continent, and in the States of America, ferro-concrete is nothing new, and many large and beautiful works have been constructed in it, but in England we have been slow to realise its advantages. Worth must, however, come to the front sooner or later, and worth in this instance is represented very largely by the cold facts of pounds, shillings and pence.

We shall, when in Paris during the coming summer, no doubt have instructive opportunities of seeing what our French confrères can do in this direction, for they are amongst, if not altogether, the pioneers in ferro-concrete construction, as one of our members very aptly mentioned at M. Canet's Inaugural Address. As an instance of what our American cousins are doing in ferro-concrete it need only be said they are now applying it in the construction of some of their loftiest buildings, a class of work hitherto constructed in steel alone. This circumstance one might add, seeing that the dollar enters so largely into the calculation, is sufficiently significant. Coming home, it is interesting to note that our own Government Departments are now adopting this form of construction, notably at the New Gunwharf Store at Portsmouth for the War Office, and in the large buildings for the Post Office Department, both in Birmingham and London.

It should not be forgotten that ferro-concrete should be looked upon as a substitute for steel rather than for concrete. It

appears unnecessary to state this, but although it is obvious in ordinary cases such as girders, in others it is less so, as for example in an arch or retaining wall. In such cases we have hitherto regarded the dead weight as largely, if not altogether, responsible in resisting the forces set up, but in dealing with similar cases in ferro-concrete the dead weight has little if anything to do with the matter, and the structure must be designed almost entirely to resist bending moment if true economy is to be obtained. By way of illustration, the case may be mentioned of a retaining wall recently completed, supporting a well-known thoroughfare in London. The actual section of the wall was in the form of the letter L, the vertical arm forming the retaining wall, which was some 25 feet deep, and had a thickness at the bottom of 30 inches, tapering to 9 inches at the top.

At present, ferro-concrete work in this country is largely carried out under a few patented systems. In several it takes the form of patented reinforcement, and in others of some special arrangement of hooking or inserting the reinforcement. No doubt these systems (so-called) have materially assisted towards an earlier realisation of ferro-concrete, but it must not be forgotten that the main principles are in themselves unpatentable, and that any engineer, especially if he be used to constructional work in steel, need have no hesitation in applying the principles in designing ferro-concrete, care being taken that more attention is given to stresses due to shear than is usually considered necessary in designing steelwork.

A good deal must necessarily be left to the judgment of the designer. Many elaborate theories and formulæ have been devised from time to time, but in all of them will be found certain assumptions. Several are based on the modulus of elasticity of the concrete, which is frequently taken at one-fifteenth that of steel, and sometimes at one-tenth, but it is obvious that this must vary with the component parts of the concrete and the quantity of cement used. Again, many formulæ recognise that the stress in the concrete is proportional to the distance from the neutral axis, but this is certainly not the case. Nevertheless, the well-known formula for plain rectangular sections, *i.e.*, $M = f\frac{bd^2}{6}$ may generally be applied, so far as the concrete is concerned, provided a suitable f is taken to correspond with the nature of the concrete and percentage of reinforcement.

It has recently been shown that with ordinary rock concrete mixed in proportion of 1-2-4, a beam with less than 2 per cent. reinforcement is far more likely to fail through the yield point of the steel having been reached than through the failure of the concrete. It need only be said that ferro-concrete is, in general, capable of being used satisfactorily for all work where steel is at present employed. The exceptions would include cases where light loads occur, such as roof trusses, &c., where the cost of centering would be prohibitive. Ferro-concrete is particularly adaptable for warehouses and factories carrying heavy loads, as T beams can be introduced freely, and the cost of timber is low in comparison.

In conclusion, the influence of ferro-concrete may be calculated to promote a much better understanding between the engineering and architectural professions than all the joint meetings which may be arranged with that object in view are likely to effect.

LEWIS H. RUGG.

OBSERVATIONS IN GENERAL.

It will be generally conceded that the engineering event of the first month of 1908, since the reliability of the 50 H.P. motor formed such an important feature in it, was Mr. Henry Farman's successful flight with his æroplane on the 13th January from the drill ground at Issy-les-Moulineaux, near Paris, during which he accomplished the closed kilometre (1,093 yards), the official time being 1 min. 28 secs., and the average elevation, 12 to 18 feet.

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He thereby became the winner of the Deutsch-Archdeacon prize of £2,000, and the recipient of other honours. Our Institution offer its congratulations to him.

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That "he is an Englishman" must of course be pleasing to us having regard to our "insular prejudices," but we must not forget that the achievement was due to the operation of French influence. But there, as we were reminded last November, "Science recognises no frontiers," and we would but rejoice at the circumstance that a further advance in solving the difficult problem of aerial navigation can be recorded.

This should lend added interest to our meeting on the 7th February, which it is hoped Mr. Farman may even yet be able to attend, although we understand that this is uncertain.

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Those other eminent workers on the subject in France—M. Julliot, the engineer who designed "La Patrie"; Capt. Ferber; and Count de la Vaulx, Vice-President of the Aero Club de France—have, however, promised to be present, and assist in the discussion, whilst Major Baden Powell, the Hon. C. S. Rolls, Dr. Hele-Shaw, Mr. S. F. Cody, and Mr. A. V. Roe are also expected.

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Several references have recently been made in *The Journal* to the New Patents and Designs Act, 1907. We notice that an article on this subject, written by one of our members, appears in Whitaker's Almanack for 1908 (p. 446), in which the novel features of the Act are reviewed.

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It becomes our sad duty this month to chronicle the deaths of Mr. J. Macfarlane Gray (Hon. Member) and Mr. Richard Forster (Member).

* * * * * *

Mr. Gray was enrolled more than seventeen years ago, and some of our older members, who had the advantage of his acquaintance will, we are sure, cherish the memory of that kindly personality, and that delightfully original and ready manner in which, during ordinary conversation, he would expatiate, with his rich fund of knowledge always at command, on practically any subject that might be introduced.

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We wonder whether we have many members in the Institution who have passed (or failed) before him in his capacity as Chief Examiner of Marine Engineers to the Board of Trade.

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It was in 1892 that Mr. Gray lectured us on "The Theta-phi Diagram of the Thermo-Dynamics of Steam," a condition of its delivery, according to the footnote on page 113, Vol. III., being that it should not be inserted in the Transactions. Who shall say that this was not another indication of his kindly consideration for us?

His son, Mr. Geo. Macfarlane Gray, in acknowledging a letter of condolence sent by our Secretary, wrote:—"It may interest you and any other friends of my father to know that his illness and end was absolutely free from pain." He was seventy-six years of age. The funeral, at which the Institution was represented by Mr. A. Knight Croad, took place at the Western Necropolis, Glasgow.

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As mentioned in *The Journal* for October, Mr. Richard Forster had left England on medical advice, and was proceeding to New Zealand. On account of the state of his health he had to remain at Cape Town, and went into the New Somerset Hospital for special treatment. His death occurred there on Christmas Day.

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He will be remembered by those who attended our West Lancashire Summer Meeting in 1902. Trained at Messrs. Newton Chambers and Co.'s Works, near Sheffield, he afterwards went to Shropshire.

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Professor Ripper, of the Engineering Department of the University of Sheffield says of him:—"He was one of the most persevering and successful students we have ever had here, and he did excellent work in the advanced classes of the various subjects in the Engineering course."

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It will be generally known that a Masonic Lodge (The Junior Engineers, No. 2,913) was founded in 1902 by some of the members of the Institution, with Mr. H. Cartwright Reid as the first W.M.

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A movement is now on foot for attaching to it a Chapter of Royal Arch Masons. Any member of the Institution belonging to that body, or who is a Mason, and willing to assist in the matter should communicate with our Secretary before the 15th February.

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Our Chairman's Paper on "Water Supply for Country Houses," which he gave before the Discussion Section of the Architectural Association, on the 15th January, proved a great

success. A good proportion of the speakers in the discussion consisted of our own members, who, as visitors, were asked to take part.

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We meet our friends the Architects again as their guests on Wednesday, 12th February, to talk over some "Suggestions as to how the Architect and Engineer can combine," which are to be introduced by our Past-Chairman, Mr. P. J. Waldram.

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On Wednesday and Thursday, 26th and 27th February (for ladies), and on Friday 28th (smoker), the Fourth Annual Architectural Association Students' Concert, &c., in aid of the Architects' Benevolent Society, takes place. Another Extravaganza is in course of preparation, and, judging from the quality of last year's, is likely to be exceedingly good. Tickets can be obtained from Mr. W. Wonnacott, 199 Piccadilly, W., or from the Secretary of the Association, Mr. Driver, 18 Tufton Street, Westminster. May the funds of the Society be largely augmented by this effort.

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Members should note Saturday, 27th June to 11th July as the dates for the Summer Meeting, which, at the suggestion of the President, who has kindly promised his assistance in the preparation of the programme, will be held in la belle France. Arrangements will be made for either a week or the whole fortnight to be taken, according to desire, as was done when we went to Germany in 1904.

The Fourth to Sixth Visits of the Twenty-seventh took place on Saturday, 14th December, 1907, the attendance being 126.

The members assembled at 3 p.m. at the Wood Lane entrance to the Franco-British Exhibition at Shepherd's Bush. With the special permission of the Executive Committee, they were shown over the whole site, enabling an inspection to be made of the buildings, stadium, &c., in process of erection, several of the officials, Mr. J. S. Ferguson (Member), representing the Contractors, Messrs. Alex. Findlay and Co., and Mr. Lewis H. Rugg (Past-Chairman), acting as guides.

They were then shown the surface plant, &c., of the Exhibition Extension Works of the Central London Railway, for which Mr. Basil P. Mott, M.Inst.C.E., is the Engineer, and afterwards, with the permission of Mr. Granville C. Cuningham, M.Inst.C.E., General Manager to the Central London Railway, were conducted over the Central London Railway Depôt and Power House, under the guidance of the Chief Engineer, Mr. E. P. Grove, the Station Engineer, Mr. Chas. Forgan, and other officers.

For all the facilities which had been extended for the benefit of the members during the afternoon, Mr. F. R. Durham, Chairman of the Institution, expressed their thanks in each instance.

FRANCO-BRITISH EXHIBITION MAIN BUILDINGS.

The whole of the constructional work was designed by Mr. John J. Webster, M.Inst.C.E., of Westminster, Messrs. Alex. Findlay and Co., being the Contractors; they have kindly furnished the following particulars:—

Machinery Hall.—This building, which covers an area of about $6\frac{1}{4}$ acres, is U-shaped in design, the two wings being 660 feet long each and 130 feet wide, joined at the south end by a building 300 feet long by 324 feet wide. Each wing is made up of three bays, the central one having a span of 50 feet, and the two outer ones of 40 feet each; the outer bays are 28 feet from the floor line to the eaves, the central bay being 37 feet, thus leaving space for clerestory windows 8 feet deep—the whole length of the building. Each bay is fitted the whole length with glazed lanterns on the top of the roof, with louvre ventilators at the sides. In addition to the above lights, window frames 8 feet deep are fitted to the whole length of the outer sides of the 40-feet spans. Large doors are fitted to the sides and ends of the building at frequent intervals.

The structure consists of braced columns firmly embedded in cement concrete foundations, supporting trusses at intervals of an average of 13 feet. The outer columns are designed to withstand, in addition to the dead-load of the structure, a wind pressure of 40 lb. per square foot acting horizontally on a vertical surface of the roof, the normal component being ascertained by the following formula—

$$u' = u \sin a \; 1{\cdot}84 \cos a - 1.$$

Where u' = normal component, u = pressure of wind on a vertical face, and a = angle of inclination of the roof with the

horizontal. The wind pressure on the sides of the building were taken at 30 lb. per square foot. The outer columns consist of two channel bars 9 inches wide and placed 24 inches apart at the bottom and tapering 14 inches at the top, with angle and flat bar bracing at the sides. These columns are placed 13 feet apart. The inner columns carrying the centre span consist of four angle bars with flat bar bracing and are 14-inch square outside. The outer columns have horizontal wall joists of rolled joists 3 inches by 2½ inches, spaced about 6 feet apart, for carrying the breeze concrete which forms the sides of the building.

The columns and roof principals, purlins, wall joists, &c., are constructed of high class open-hearth steel, having a breaking-load of about 32 tons per square inch ; all the ventilator frames, windows, &c., are wrought iron, the whole building being thus constructed of fire-proof materials. The roofs are covered with corrugated sheeting and Mellowes' glazing.

Stadium.—One of the principal features of the Exhibition will undoubtedly be the Stadium, in which the Olympic games will be held. The building in plan has two straight sides with circular ends. The outside dimensions are 1,000 feet long by 594 feet wide. The seating and standing accommodation is 75 feet wide, and consists of 32 tiers for seats and 65 tiers for standing, the standing portion being at the circular ends of the building, and the seating at the flat sides, the whole being thus capable of accommodating 75,000 people. There is an open space 10 feet wide in front of the seats running round the building, from which are numerous entrances or exits underneath the platforms, special entrances and accommodation being made for Royalty. There is a cycling track 33 feet wide ramped at the ends, a cinder running track, 25 feet wide, and a swimming tank 330 feet long by 50 feet wide, being specially constructed for high diving ; the other space is covered with fine grass turf.

In the construction of the stadium, the main frames are spaced about 20 feet apart, and consist of rolled steel joisted rakers, 15 inches deep, supported on seven columns built of two channels latticed together on both sides and flat bracing bars, the columns being securely built to the concrete foundations.

The risers consist of channel bars, 9 inches by 3 inches, of varying weight according to the span, the latter increasing from the front at the curved ends. They are spaced from 2 feet

4 inches to 2 feet 6 inches, according to the position, and are fixed to the rakers by means of forged stools. The platforms consist of reinforced concrete averaging 2 inches thick, the enclosed steel bars being indented bars $\frac{1}{3}$ inch square, spaced about 12 inches apart, the whole of the concrete being laid *in situ*. Timber lath seats are fixed to the concrete. The side of the building where the seating accommodation is, will be roofed over by trusses, 61 feet 8 inches in span, with an overhang of 17 feet 10$\frac{1}{2}$ inches, and covered with corrugated sheets.

The space underneath the platforms will be fitted out for the accommodation of competitors, dressing rooms, lavatories, offices, refreshment rooms and exhibit stalls for various goods pertaining to athletic games, the outside face being covered with plaster work of an ornamental character.

Agricultural Hall.—This building consists of one main building 427 feet 6 inches long by 130 feet wide, with an annexe at each end 123 feet long by 67 feet 6 inches wide, the main building being for exhibits, and the two annexes for restaurants, the kitchen, 123 feet long by 13 feet wide being attached to the side of one of the annexes. In front of the main building and the annexes is fixed a circular loggia, 14 feet wide, supported on ornamental columns, this being extended round the end of the annexes, and in the centre of the main front over the main entrance is fixed a high ornamental dome and towers, which involved special constructional work. At the front end of each annexe ornamental towers are fixed at each corner. The roof trusses of the annexes are in one span of 67 feet 6 inches. The constructional work of the main building is very similar to that of the Machinery Hall, the columns and roof trusses being of similar design, the spans of the roof and the spacing of the columns, &c., being the same. There is a high rectangular lantern in the centre of the building 50 feet square, glazed on the top and covered with sheeting at the sides. The sides of the building are covered with breeze concrete 3 inches thick, the concrete being previously made in the form of slabs. The building will be covered with plaster work of great architectual beauty.

Indian Court.—This section consists of two main buildings 400 feet long by 130 feet wide, spaced 252 feet apart and joined at the end with irregular shaped buildings, the whole block of

buildings enclosing the space, in which are the ornamental gardens with large lake, as shown on the general plan appended. A loggia, 14 feet wide is fixed in front of the buildings next the enclosed space. The construction of the buildings is of similar design to that of the other buildings, the span of the roof trusses, and the spacing of the columns, &c., being the same. There is a large raised lantern 50 feet square in the centre of each building, and there is a special construction for the ornamental towers in various positions in the facade. The buildings are lighted at the sides and in the roof, and louvre ventilators are fixed in the sides of the raised lantern.

Mr. Cuningham has kindly supplied the following:—

CENTRAL LONDON RAILWAY.

The Central London Railway runs from Shepherd's Bush on the West side of London to the Bank in the centre of the City, a distance of nearly six miles. The "up" line and the "down" line are carried in separate tunnels, each having a diameter of 11 feet 8 inches. The tunnels are constructed on the line of the Uxbridge Road, Bayswater Road, Oxford Street, Holborn, and Cheapside, at a depth below the street surface varying from 60 to 100 feet.

The first Act authorising the construction of the railway was obtained in 1891; work was begun in 1894, and the line was opened for traffic on the 30th July, 1900. The two tunnels are pierced in the London clay, and are formed of segments of cast-iron bolted together. The station tunnels are 23 feet in diameter, and these, as well as the entrance passages, are lined with glazed white tiles.

The system of fares adopted on the opening of the line was a uniform "2d. for any distance," with "no class," and this having been continued for seven years has been eminently successful in securing large numbers of passengers, and has proved a great public convenience. Recently, however, owing to a decrease in the numbers carried, the uniform fare has been abandoned, and fares of 2d. and 3d. substituted.

The service was first started with trains drawn by electric locomotives; each train consisted of seven cars, of the non-compartment type, weighing 14 tons, and giving seating accommodation for 48 passengers each, drawn by a locomotive weighing 42 tons, making a total weight of train of 140 tons. It was found that the heavy locomotive caused vibration in the tunnels,

which was communicated to the surface, and gave rise to complaints. After an exhaustive enquiry by a committee, subject to the Board of Trade, it was determined to substitute electric motor cars for the locomotives, and to adopt the system of "multiple control," by which, from one point of control in the train different cars could be actuated. By the month of June, 1903, the change to the new system was completed, and the use of the locomotives entirely dispensed with.

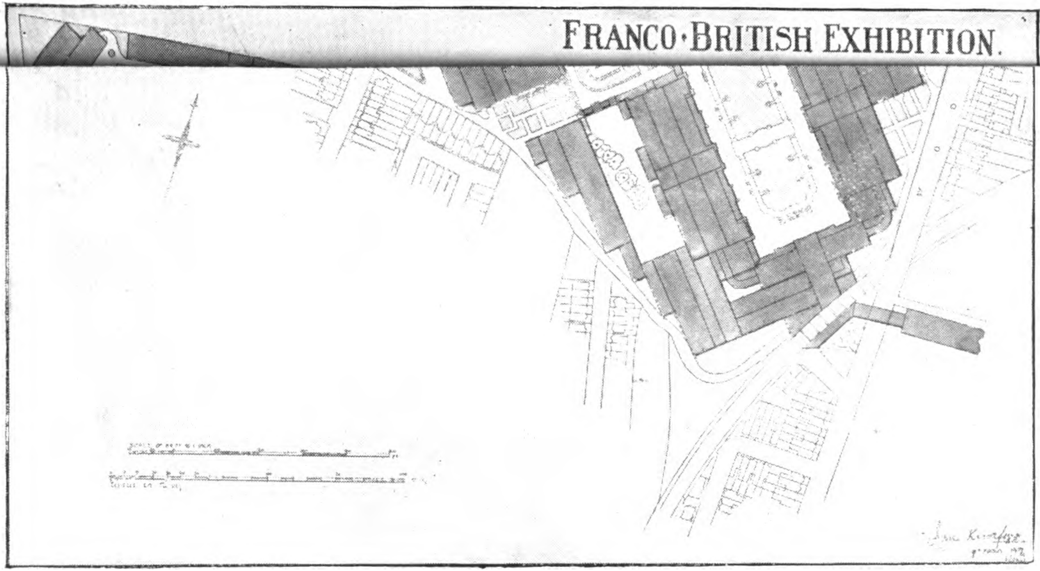
The trains are now arranged with a motor car at each end, in such manner that the leading truck in the front of the train is fitted with motors, and the last truck at the rear of the train in like manner. The driver, stationed in the motor cab of the leading car, controls both the motors of that car as well as those in the rear of the train. The system of control used is that known as the "General Electric." The weight of the motor car is 23 tons, 16 tons for the motor end of the car and 7 tons for the other end; and the train is made up of two motor cars and five intermediate cars, so that the total weight of train is 116 tons, as compared with the previous 140. This reduction in weight necessarily makes a marked difference in the monthly amount of ton miles.

The train service begins at 5 a.m. each morning from Shepherd's Bush, and the last train from there is at 12.5 midnight. The first train from the Bank in the morning is at 5.20, and the last at night at 12.30 a.m.

The distance from Shepherd's Bush to the Bank (5·77 miles) is traversed in 22 minutes, and 11 stops are made, averaging 12 seconds each. The maximum running speed between stations is 23 to 24 miles per hour. The acceleration of the motors is 1 foot per second, per second, so that at the end of 30 seconds the train has attained a speed of 30 feet per second, or 1,800 feet per minute, or 20½ miles per hour. The train thus attains nearly full speed in half a minute, which is a few seconds more than the time required to run out of a station.

The maximum service given is a train every two minutes, or 30 trains per hour, leaving the Bank or Shepherd's Bush. This service is maintained throughout the two busy morning hours, from 8 to 10, and the two busy hours of the evening, from 5 to 7; and this service can be given with 26 trains in the tunnel. At other times of the day, when the traffic is less crowded, a service

VISIT: FRANCO-BRITISH EXHIBITION BUILDINGS.



of 3 to 3½ minutes' interval suffices, and this can be maintained with 16 to 19 trains in the tunnels.

The passengers number about 115,000 to 120,000 per diem for week-days. The statistics for the six months ended 30th June last are as follows:—

Passengers	20,226,348
Train miles	638,419
Car miles	4,011,889
Ton miles	67,658,088
Passengers per train mile	31·68

Taking this average of passengers per train mile, and the length of route from Shepherd's Bush to the Bank (5·77 miles), there is an average of 183 passengers per train, on each trip; and as the seating accommodation of each train is 300, one may say that on an average, every train is about two-thirds filled on every trip. Of course, as a matter of fact, the east-bound traffic is much the heavier in the morning, and the west-bound in the evening, but the above is the average loading of the trains and is unusually satisfactory.

As there are no loops at the Bank the change from the "up" to the "down" line has to be effected by "cross-over" switches.

The rolling stock consists of 170 passenger cars and 64 motor cars: this gives 32 complete trains with ten spare passenger cars. All the rolling stock was constructed in England. Attention has been turned of late to steel-framed and steel-plated cars, and it may be of interest to know that for the past four and a half years six cars of this style, built to the designs of the General Manager of the Central London Railway, have been running most satisfactorily on the system. The frame is steel; outside panelling thin steel plate; roof, sheet steel, lined with asbestos millboard. The advantages of this car are: (1) lightness and rigidity; it is 12 cwt. lighter than an ordinary car; (2) non-liability to fire; (3) greater internal space; owing to the thinness of the walls the car is 4½ inches wider inside than the others, the outside dimensions being the same.

The power to operate the system is produced in a generating station situated at Shepherd's Bush. Here the current is generated at 5,000 volts alternating, and is sent out to transforming stations placed along the route at Notting Hill Gate, Marble Arch, Bond Street, and Post Office, where it is reduced to

550 volts direct, and at this pressure delivered on the line and used in the motors. The system of distribution is by a central rail laid between the two running rails, and the return current is carried by these latter.

The generating engines in the main house are six horizontal, cross compound, condensing machines, made by Allis, of Milwaukee, U.S.A., running at 96 revolutions per minute. The electric generator is fixed directly on the fly-wheel shaft. Each is of 850 KW. capacity, or about 1,000 H.P.

The average output of current is 738 units per engine hour, and as the normal capacity of each engine is 850 units, it will be seen that the actual output bears a very high proportion to the possible normal. The output for a day in the winter months is about 58,000 K.W.H. The grand total output for the six months ended 30th June last was 9,414,727 units.

In connection with the new engine, the erection of which has only just been commenced by Messrs. Musgrave's, this will have drop valve gear, and will also drive its own air and circulating pumps off the tail rods. For this engine a barometric condenser is being installed by Messrs. Mirrlees Watson. This is also provided with a separate steam-driven dry air pump and centrifugal circulating pumps, so that the condenser can be used on the Allis engines, the exhaust pipe being connected through; in future, therefore, it will have a condenser at each end of it.

Another interesting feature is the boiler house feed water meter, which is of the Venturi pattern, made by George Kent. This is an indicating as well as an integrating recording meter. Another Venturi meter of the indicating type only has been installed in the circulating discharge to the cooling tower for the new condensing plant. Recently, chain grate stokers have been installed on eight of the Babcock and Wilcox boilers.

Not more than five engines are required at the time of greatest load, so that there is always an ample reserve of power. The boiler house contains 16 Babcock & Wilcox water-tube boilers, and four Lancashire boilers.

Besides Klein towers for cooling the condensing water, there is a Wheeler tower, to which originally forced draught was applied, but it is now being converted to natural draught. A large brick cooling tower has recently been put into service for cooling 200,000 gallons per hour. It was built to designs sub-

mitted by Messrs. Balche and Co., who supplied the irrigation system for the interior, after some modifications had been made by Mr. H. F. Parshall, the Consulting Engineer to the Central London Railway.

The condensing plant is specially interesting, as it is a central system, having one large exhaust pipe common to the Allis engines, discharging the steam into two large surface condensers, each 9,000 square feet cooling surface, erected vertically at the north end of the engine house, with open tops, the water being pumped by three triple expansion Worthington pumps direct to the cooling towers, the Edwardes' air pumps being driven without gearing by 500 volt direct current motors.

The water supply is obtained from two artesian wells on the premises, one with a deep well pump, the other very efficiently worked by the compressed air lift system. The supply obtained from each well is about 5,000 gallons per hour.

The coal used is smokeless Welsh washed peas, Shipley peas and slack, and Insdale slack. Chain grate stokers are attached to the boilers, under which soft coal is burnt, and their use entirely avoids the production of smoke.

Besides the power production directly from the generating station, storage batteries are maintained to supply power for emergency lighting. These batteries are installed at Queen's Road, Bond Street, and Post Office stations, and in the event of power going off from the main supply, the current from these battery stations is immediately switched on, so as to keep up the lighting throughout the system.

Car sheds for the storage and overhaul of all trains are constructed at the Shepherd's Bush Depôt, where the power house is situated. Here, too, are the repair shops fitted with machine tools for the repair of the rolling stock.

CENTRAL LONDON RAILWAY.—SHEPHERD'S BUSH EXTENSION.

Mr. Mott has kindly supplied the following:—

The extension of the Central London Railway, authorised by Act of Parliament in July, 1907, will form a very important

addition to the Company's existing lines inasmuch as a direct connection will be provided to the Franco-British Exhibition. In addition, as the extension forms a "loop," the shunting operations now in vogue at Shepherd's Bush will be dispensed with, and much time saved.

The new works consist of about 580 lineal yards of tunnel and 80 yards of open cutting. The tunnels, which are circular in section, have an internal diameter of 11 feet $8\frac{1}{4}$ inches on the straight and 12 feet 7 inches on the curves, to allow for the extra overhang of the coaches. Four faces are being worked ; two of them being in water bearing strata are being driven under compressed air. The excavation for the open cutting is taken out in the usual way, and well punned concrete invert and retaining walls put in length by length.

As part of the scheme the existing open cutting is being widened out so as to get in an additional road for emergency and shunting purposes. The new line, when laid, will have three connections to the carriage sidings in the Depôt, so that a ready means of withdrawing any train or trains from service will be provided. Where the line comes to the surface a single line station is to be built, consisting of two platforms, one of which will be used for the exit from and the other for entrance to the trains.

Following now the course of a train arriving at Shepherd's Bush Station. On leaving the station the train will go up through what is known as the Depôt tunnel, an open cutting (as at present used for getting trains up or down from the main line) into the new station, the entrance to which is immediately opposite the main entrance to the Exhibition. Thence passing down through the new open cutting into the new tunnel, the line crosses under the Depôt tunnel above referred to into the existing shunt tunnel, emerging finally into the up-platform of Shepherd's Bush Station.

The construction of the new works is under the supervision of Mr. Basil Mott and Mr. David Hay, the Company's Consulting Engineers, and the Resident Engineer is Mr. H. J. Deane ; Messrs. John Mowlem and Co., are the contractors.

ELECTRIC TRAMWAY CONSTRUCTION.

The Fourth Ordinary Meeting of the Twenty-seventh Session was held at the Society of Arts, John Street, Adelphi, on Wednesday, 8th January, 1908, the attendance being 102.

The chair was taken at 8 p.m. by Mr. Frank R. Durham (Chairman), and the minutes of the previous meeting of 10th December last were read, confirmed, and signed.

The Chairman referred in feeling terms to the death of Lord Kelvin, which had occurred since the last meeting, and moved the following resolution, which was passed in solemn silence, the members rising from their seats:—

> "That the Members of the Junior Institution of Engineers record how deeply they feel the very great loss which they have sustained by the death of Lord Kelvin, who had been a beloved and revered Vice-President of the Institution since 1895; and that they respectfully tender to Lady Kelvin the expression of their sincere sympathy with her in her bereavement."

The following names of those elected to the Institution since the last meeting were announced:—

Members.

John James Nesbit Brown	South Norwood.
John Henry Drew	Audenshaw.
Herbert William Jackson	Coventry.
Sidney David Lancaster	Snaresbrook.
George Hart Milton	Coventry.
Thomas Edward Robertson	Catford.
Frank Reginald Swain	South Kensington.
James Wallis	Cheam.
Sydney James Walter	New Wanstead.
Thomas Aubrey Watson	Purley.

Associates.

John William Donald Cook	Ealing.
Leslie McGowan Haybittel	Brixton.
Ernest Sidney Huntingford	Twickenham.
Lauret Marshall Jockel	Edinburgh.
Cuppersawmy Naidu Varada Rajalu Naidu	Erode, Madras.
Angus Niel Paterson	Charlton.
George Taylor	New Cross.
Charles Fred Vickers	Earlsfield.

A Paper on "The Conduit System of Electric Tramway Construction, and Recent Improvements" was read by Mr. Fitz Roy Roose, A.M.I.Mech.E., A.M.I.E.E., F.C.S., of the London County Council Engineer's Department.

The discussion upon it was opened by Mr. L. H. Rugg, who proposed a vote of thanks to the author for his paper. Seconded by Mr. F. D. Napier, who continued the discussion, it was passed by acclamation. The other speakers were Messrs. H. C. King, W. H. De Ritter, C. Singleton, R. Marshall, E. Boult, Alex. Millar, A. W. Marshall, C. H. Smith, P. Brown and the Chairman.

The author having replied, the proceedings terminated with the announcement of the ensuing visits on the 11th January to the Tramway Re-construction work in progress in Stockwell Road, South Lambeth, and the Clapham Road Motor School, Car Sheds and Sub-station; and of the ensuing meeting on the 7th February, when a Paper on "Aerial Navigation" would be read by Mr. Herbert Chatley, of Portsmouth.

MEETING OF MEMBERS AT BIRMINGHAM.

The Third Meeting of the Birmingham members and their friends was held at the headquarters of the Electrical Engineer Volunteers, Birmingham Detachment (by permission), on Wednesday, 15th January, 1908, at 8 p.m., Mr. H. J. Poole in the chair, the attendance being four members and six visitors. The minutes of the previous meeting were read by Mr. R. B. A. Ellis, confirmed, and signed.

The chairman then called upon Mr. Ellis to read Mr. Fitz Roy Roose's paper on "The Conduit System of Electric Tramway Construction, and Recent Improvements."

At its conclusion, Mr. E. A. Dowson proposed a vote of thanks to the author for his excellent paper, and considered that the conduit system was much simpler than the overhead. In regard to the position of the plough in relation to the car, he pointed out that should the plough frame be placed near one of the bogies, the plough would have less lateral or transverse motion on curves, and believed he was correct in saying that on curves the slot rails were not laid in the middle of the track. An important

advantage possessed by the overhead system, was that in case of derailments the car was easily put back on the track, whereas with derailments on the conduit system the plough sustained damage. The necessity of pulling up the road to get at the insulators seemed to him an arrangement open to criticism.

Mr. Boggust (Visitor) seconded the vote of thanks, and thought that considerations of the high cost of construction and of maintenance, were sufficient to put the conduit system out of court.

Mr. T. H. Relton (Member) exhibited some illustrations from "The Electrical Review," of the original track mentioned in the paper, and raised the following points on which he would like to have the author's views:—That the current leakage must be great owing to insufficient surface on the insulators, especially as they were subjected to a deposit of damp dust. The test applied to the insulators before erection seemed too low, considering the conditions under which they had to work, as 500 volt apparatus working in an engine room under favourable circumstances had to withstand a test of 2,000 volts for one hour at least. Blinking was inconvenient, and should be avoided by possibly using two ploughs. Why should not an alternating system be used?

Mr. Ellis considered that the silent and smooth running of the conduit system a great feature in its favour.

The Chairman, in supporting the vote of thanks, thought the paper was excellently prepared, and the diagrams illustrating it extremely clear.

A vote of thanks was passed to the Chairman on the proposal of Mr. Dowson, seconded by Mr. Jeavons.

The Chairman having replied, the proceedings terminated with the announcement of the ensuing meetings on February 7th and 20th.

NOTES ON THE CALUMET AND HECLA MINE.*

BY ERNEST PENBERTHY (Member), of Painesdale, Michigan, U.S.A.

The Calumet and Hecla Mine, so called, really comprises a number of mines. It contains 21 shafts, of which 15 are working,

*In these Notes the writer, who is engaged with the Copper Range Consolidated Co., has made free use of the "Copper Handbook" by Horace Stevens.

2 are idle, and 4 are permanently abandoned. The twenty-second shaft is now in course of sinking. Pillars 75 feet wide are left on either side of every shaft, and, when the present conglomerate workings are exhausted, will give a product equal to about 18 per cent. of all the rock mined previously. The mine is opened for a period of about eight years in advance of immediate requirements. There are some 200 miles of shafts, drafts, winzes and cross-cuts. About 300,000,000 feet of timber are used annually. Electric pumps are installed in the No. 7 Hecla Shaft. Much damage has been done in the past by underground fires, and now every possible precaution is taken against mine fires, including the partial fire-proofing of all mine timber, with chloride of zinc solution, regular sprinkling of all shafts, the maintenance of water pipes and hydrants, fire-hose, chemical engines, an electric alarm system, and eighteen telephones at various pump stations.

The Red Jacket vertical shaft, 4,920 feet deep, started in 1888, cut the lode at 3,287 feet. It has an 8,000 H.P. quadruple hoist housed in a 70 feet by 220 feet brownstone building, and in an adjoining brownstone building of 70 feet by 150 feet, with a 250 feet smoke stack of 12 feet 6 inches diameter, are ten 1,000 H.P. boilers. At the rear of the engine house is a 32 feet by 412 feet brownstone annexe, floored with cement and roofed with slate, in which is carried the fleet gear. In raising 10-ton loads perpendicularly from a depth of one mile, the weight of the cage and steel cable nearly equals that of the cargo of rock, but with the aid of counterbalance the engines can hoist 10-ton loads at a speed of 40 miles per hour, the regular hoisting time being about 90 secs. for the vertical distance of nearly a mile, this including time taken for starting and stopping. This engine operates on the well-known Whiting system, devised by S. B. Whiting, formerly General Manager of the Company. To overcome the dangerous strain caused by unequal wearing, Walker differential rings have been placed on the sheaves with excellent results, the cables taking four complete turns round the driving sheaves. The Red Jacket steel combination shaft rock-house, 100 feet square and 110 feet high, is fitted with breakers capable of crushing 2,000 tons of rock daily.

(*To be concluded in the March Journal.*)

The Junior Institution of Engineers.

"THE CONDUIT SYSTEM OF ELECTRIC TRAMWAY CONSTRUCTION, AND RECENT IMPROVEMENTS."

By FITZ ROY ROOSE, A.M.I.Mech.E., A.M.I.E.E., F.C.S. (L.C.C. Engineer's Department).

Read 8th January, 1908.

Since the paper on the reconstruction of the London County Council tramways, by Mr. Alexander Millar, Assoc.M.Inst.C.E., was read before the Institution of Civil Engineers, in 1904,* many new lines have been constructed, and reconstructions carried out. Improvements and modifications have been made, which from experience have been found possible and advantageous, having regard to firmer construction, longer life, and cheaper maintenance.

It is the author's intention to avoid as far as possible, repetition of the details contained in Mr. Millar's paper, and to confine himself to a comparison of the original method of construction of the conduit system with that at present in vogue.

In the year 1903 there were in South London 16·4 miles (single) of tramways on the conduit system, and since then about 88 miles have been constructed and reconstructed, making a total of 104 miles (single) to date, while on the north side of the Thames about 50 miles have been constructed and reconstructed. The work of reconstruction is still proceeding.

The electrified lines have been extended over Vauxhall Bridge to Victoria, and over Westminster Bridge along the Embankment to Blackfriars, and an important subway has been formed between Holborn and Aldwych, under Kingsway. An extension to the latter is now in progress to connect with the Embankment under Waterloo Bridge, passing under the Strand, which, when completed, will link the Southern and Northern systems.

*Proceedings, Inst.C.E., Vol. CLVI., p. 143.

ORIGINAL METHOD OF CONSTRUCTION.

The first line constructed from Westminster to Tooting, via Clapham, and opened in 1903, consisted of a concrete tube in which were embedded iron yokes, 3 feet 9 inches apart, supporting two central rails $\frac{3}{4}$ inch apart, and level with the road, thus forming an opening in the road surface through which access to the tube for the electrical connection was obtained. These two rails, known as "slot rails," were held in position on the yokes by bolts, and kept to uniform gauge by tie rods, extending between a shoulder on the yoke and the rail itself. The slot rails, yokes, and conduit were all combined in one operation. The slot rails and yokes having been assembled, and brought to the required line and level, a centering, formed of laths of wood, and shaped to fit the inside contour of the yokes, was inserted and wedged in position. Wooden or sheet iron frames were hung from each slot rail at intervals of 15 feet, to form pockets known as insulator pits. The whole structure was then surrounded by a mixture of 5 to 1 concrete. When the concrete was thoroughly set, the wooden centering and box frames were drawn. A concrete conduit was thus formed with a pocket on either side every 15 feet, surmounted by the slot rails. The track rails were then laid to accurate gauge, on either side of the conduit, and packed up on 9 inches of 7 to 1 concrete, tie rods being inserted between each track rail and yoke, to maintain the gauge. Under every joint between the track rails a sole plate or anchor was riveted and embedded in 3 to 1 concrete. (These were not actually used on the Tooting lines, but on the Camberwell lines, which were laid about the same time.) Dicker joints were adopted on the Tooting lines. Later lines, however, had ordinary fish-plates and anchors. Cast-iron frames and covers were bedded against the slot rails over each pocket formed in the conduit. Paving was then laid. The conductor bars (tee rails) were next put in to the conduits through a gap, a 7 foot 6 inch length of slot rail being left out temporarily for the purpose. Insulators were bolted to the flange of the slot rail in each pocket, and the conductor bars were fixed by clips to the insulator, and thus presented two rubbing surfaces, which, when brought to gauge, were 6 inches apart. At each joint between the conductor bars, two copper bonds were riveted, bridging the joints, ensuring a continuous conductor. (Figs. 3 and 4, Plate 1.)

At intervals of half a mile, a gap of 2 feet was left in the conductor bars, forming a section insulator, at which point current was supplied to the line.

The ends of the conductor bars were flared back 1½ inch, the distance between the extremities of the bars thus being increased to 9 inches. This was done to ensure that the plough, after leaving one section, should slide between the bars of the next without catching. For greater stability, and to withstand the shock caused by the plough entering between the flared ends, two insulators, contained in a larger pocket, supported the flared ends. From each bar on each side of the break thus formed, a cable in an earthenware duct was taken to a feeder pillar erected on the footpath, and from which current was obtained, the feeder pillar being in turn fed from a sub-station supplied with power from a generating station. Switches were placed in these feeder pillars so that current could be cut off the conductor bars when necessary. At each of these section insulators, covers, known as "plough hatches" were fixed, which, when removed, formed a gap large enough to permit of a plough being withdrawn from the conduit.

The plough, a collecting device (connected by cable to the car motors) was suspended from each car. It passed through the slot and terminated in two rubbing contacts called shoes, which by means of springs, were pressed out against the conductor bars, and thus completed the circuit between the conductor bars and the motors in the cars.

At intervals of about 60 yards, the ordinary insulator pits in each track were deepened and connected by means of a 12 inch pipe, with sumps or catch-pits, built in the margin of the tramway. These sumps formed settling chambers for the mud; the water flowing to the sewer through a 12 inch pipe, which was trapped at the sump end, to prevent sewer gas escaping to the road. A manhole cover in the road gave access to the sumps for cleaning purposes. The track rails were drained by means of holes drilled in the floor of the groove of the rail, into cast-iron boxes, bolted against the web of the rail, which in turn were drained into the tube itself through 3 inch pipes.

The frames of the catchpits were the same as the ordinary insulator pit frames, but had special covers, which allowed of the insulator being placed to one side of the pit, instead of centrally,

thus facilitating cleaning operations. Crossovers and junctions were constructed with special castings, special yokes being supplied, enabling one conduit to diverge from the other and thus follow the track branching off from the main line.

At all facing and trailing points a chamber, termed a mechanism pit, was built under the whole width of the track, in which all connecting rods and necessary mechanism for actuating the points, both slot and track, were installed. These pits extended 3 feet outside the outer rail and were drained into the nearest sump or direct into the sewer. At facing points of junctions, the rod in the mechanism pit actuating the track and slot points, was extended through a pipe to a lever box in the footpath, from which it could be operated.

Adjacent to the mechanism box, a small pit was built of concrete, containing a tap and length of hose terminating in a nozzle, which was used for cleansing the points, being connected through a meter to a convenient water main.

The conductor bar work for crossovers and junctions was necessarily somewhat complicated, as provision had to be made for the plough branching from one conduit into another. This was done by having gaps in the bars, the ends of which were flared wherever the slots intersected or converged.

To continue the current across these gaps, "Jumper" cables were drawn through earthenware pipes and bolted on to each conductor bar, ensuring continuity of current.

The insulators, which suspended the conductor bars, consisted of three separate parts; an iron hood, corrugated on the inside surface, with a projecting bolting-up face containing two holes for bolting up to the slot rail; a porcelain cup, also corrugated; and a corrugated spindle or pin. The three parts were assembled by first placing the porcelain cup in the cast-iron hood and packing round with neat cement. When the cement had set, the pin was placed in a central upright position in the porcelain cup, and was in turn surrounded with neat cement.

Thus was formed, when placed in position, an insulated bolt at right angles to the slot rail, on which a clip was secured. This clip (Figs. 5 to 7, Plate 1), made of cast-iron, clasped the stalk of the conductor bar—the bar being held in position by a cottar pin driven through convenient holes in the clip.

DIFFERENCES BETWEEN EARLY AND PRESENT CONSTRUCTION.

Conduit.—The conduit (Figs. 1 and 2, Plate 1) is now made 1 foot 4 inches wide instead of 1 foot 2 inches, as with the latter it was found there was not enough clearance between the conductor bars and the side of the conduit, mud accumulating and causing leakage of current. The filling used is 6 to 1 concrete, instead of 5 to 1, for reasons stated later.

Yokes.—The yokes are of two patterns (a short and an extended). The short one (Fig. 35, Plate 7), with the exception of an extra 2 inches in width to ensure greater air gap behind the conductor bars, is similar to the original pattern. It is made of cast-iron, and in section takes the form of an H girder, the web being $\frac{5}{8}$ inch in thickness, and the inner flange $\frac{3}{4}$ inch in thickness, and 3 inches in width; the outer flange is $\frac{3}{4}$ inch thick at the outer edge, increasing to 1 inch at the web, and varies from $5\frac{1}{4}$ inches to $5\frac{1}{2}$ inches at its greatest width. The overall depth of the section is 6 inches. The yoke terminates at its top, in two bolting-up faces, leaving a gap of $4\frac{1}{2}$ inches; to each of these faces the slot rails are bolted. These short yokes are placed in the trench at distances of 7 feet 6 inches, and alternately, at distances of 7 feet 6 inches apart, extended yokes, 6 feet 3 inches from tip to tip (Fig. 36), are placed.

The extended yokes, besides carrying the slot rails, form anchors, to which the track rails are fixed every 7 feet 6 inches. They are similar to the short yokes with the exception of the two extended arms, each of which terminates in a bolting-up face 14 inches by 7 inches, each containing two slotted holes, 2 inches by $\frac{7}{8}$ inch. The bolting-up face is recessed to take a hardwood packing $\frac{5}{8}$ inch thick. After placing the yokes in the trench, the slot rails are bolted on, and tie-rods are fixed between the shoulders of the short yokes and the slot rail. Track rails are laid on the extended yokes, tie-rods being used at the yokes to connect the slot and the track rails. The rails are bolted down at each extended arm by two rail clamps (Figs. 38 and 39, Plate 7), held in place by four $\frac{3}{4}$ inch tee headed bolts. The clamps, of cast steel, are each 5 inches by 6 inches, and are recessed to fit the flange of the rail and to sit on the bolting-up face. They are kept tight against the flange of the rail by tapered wedges and packing-pieces. To ensure that these shall not rise up when the rails are being brought to gauge, the shoulder of the extended

arm is undercut $\frac{5}{16}$ inch at the bottom. The wedges are also kept from slipping out by the ends being turned over.

The tie-rods (Fig. 36) are of wrought iron. Taper washers are provided to compensate for the angle at which the tie-rods meet the rails, ensuring the bolt going tight up, and not binding on one edge only.

When the track and slot rails are in position, the whole is packed up to line and level, and the yokes are stuck with 6 to 1 concrete.

Centering.—The centering is then put in, and its construction differs considerably from that at first used. As already stated, it was originally of wood, resulting in a rather rough surface to the conduit, which was not infrequently damaged in the removal of the centering.

The centering now employed is of $\frac{1}{8}$ inch sheet iron, and the methods of insertion and extraction vary. One system consists of three iron sheets, 3 feet 9 inches long, which dovetail into each other, and are pressed out to the contour of the yokes by means of wooden wedges. The chief objection to this form of centering is that as it is withdrawn in separate pieces, sections are apt to be overlooked, and in some cases months have elapsed before they have been discovered.

Another, and in the author's opinion a better device, is that consisting of two iron sheets hinged together at the bottom and pressed out to the contour of the yokes by means of a toggle joint, the arms of which are bolted to each sheet at either end. This is extracted in one operation, the whole centering collapsing on the joint being wrenched upwards, and it can be withdrawn through gaps left for the purpose.

The centering having been inserted, the rough packings are removed from under the yokes and rails; concrete is introduced in one mass at 6 to 1 instead of, as formerly, in two operations and of different mixtures. This has the advantage of speed and saving of material.

Insulator Pockets, &c.—The insulator pockets, instead of being covered by cast-iron boxes, are now covered with a cast-iron plate. (Figs. 22 and 23, Plate 5.) This plate is 2 feet by 1 foot 8 inches in area, and $\frac{3}{4}$ inch thick. It has strengthening ribs 2 inches deep and $\frac{5}{8}$ inch thick running longitudinally and

transversely, and a portion of the front edge next the slot rail is recessed to clear the insulator.

At its two extreme front ends it has holes 2 inches in diameter, to clear the clip bolts supporting the paving plates between the yokes and box. Also at either end, where the cover plate rests on the slot rail, it is tapered up $\frac{1}{4}$ inch for the insertion of a chisel point, should it be necessary to lift the cover.

Before the cover plates are bedded in position the conductor tee rail work is inserted, as previously described, two improvements having been adopted, one being that the end of each tee rail is bevelled off, minimising the chance of plough shoes being caught by foul joints ; the other being that the tee rail, with the exception of the rubbing surface, is coated with a preservative paint. Paving plates (Figs. 24 and 25, Plate 5) are inserted between the cover and yokes to support the paving, as the concrete of the conduit next the slot rail flange at this point is very thin and liable to crumble away. Before they were introduced the green concrete sometimes broke off, and the paving collapsed.

The paving is next laid. The positions of the insulator pits thus hidden, are indicated by square sets known as "dumplings."

These covers are considered a great improvement in some ways on the original boxes, which latter, as they became worn by the traffic, had to be replaced, and were also the cause of a great deal of dirt getting into the conduit. The chief disadvantage of the new covers, and one which may prove most serious, is that access to the insulators can only be obtained by ripping up the paving, which takes time ; and in the case of a rail dropping or an insulator burning out, means considerable delay in the car traffic. In the older method of boxes, an insulator could be taken out, examined, and replaced in a few minutes. It now takes—from experiments made—three-quarters of an hour.

There are only a few miles laid with cover plates at the present time, and it remains to be seen whether they will be universally adopted.

The anchor plates at the track rail joints, instead of being riveted to the rail flange, are now bolted, a process which saves time and cost in maintenance.

Drainage.—Drainage is effected by means of sumps (Figs. 14 to 16, Plate 3), spaced every 40 yards along the track, instead of 60 yards, as was formerly the case. The sump consists of a

concrete pit 7 feet 9 inches deep, built in the clear way. At a height of 3 feet 6 inches from the bottom, a concrete shelf or benching, branches off under each tube.

The conduit does not run continuously through the sump, but ends flush with each wall, enabling mud to be drawn and dropped on to the shelf in each sump, from which it can be removed periodically. A flushing box is provided over each shelf, access to which is obtained through an ordinary insulator frame and cover, and the sump is entered through a manhole, 1 foot 6 inches square, step irons being provided.

The catch-pit thus formed is connected to the sewer by a 9 inch pipe, the sill of which is 2 feet 5 inches above the bottom of the catch-pit. The mouth of this pipe is sealed with an iron hood, which extends 5 inches below the water line, thus preventing escape of sewer gas. In outfall sewers liable to flooding, iron non-return valves are inserted to prevent water, &c., getting back into the conduits in the event of the sewer becoming surcharged.

This form of sump is an improvement on its predecessor, as the benchings which now replace the 12 inch pipe, trap the mud more readily, and are infinitely easier to clean.

Rail drains (Fig. 17) are, with one or two slight modifications, similar to those originally used. The iron work being erected in one operation is a great advantage, as a much truer line and level is obtained, and with the extended yokes placed every 7 feet 6 inches the running rails have a much firmer base and are at the same time much more rigidly anchored into the concrete bed. Renewals can also be executed with greater facility.

Insulators.—One or two improvements have been adopted in the construction and erection of insulators. (Figs. 26 to 29, Plate 5.) The pin is now made with a square shoulder to prevent turning when being bolted up; there is also a piece of $\frac{3}{16}$ inch galvanised iron wire threaded through a hole in the end of the pin and twisted round to prevent the bottom nut working loose and falling off, in which case the conductor bar, losing its support, would become detached from its proper position. The usual split pin is not employed here, as any shock tending to loosen the insulator pin in its cement setting must of course be avoided.

The cement filling is now only inserted to within $\frac{3}{4}$ inch of

the top of the porcelain cup instead of $\frac{3}{8}$ inch as formerly, as it was found that moisture collected here, and leakage of current occurred, sometimes resulting in a burnt out insulator.

With the exception of these slight alterations, the insulators retain their original design. When the insulators are assembled, they are left to set for eight weeks, and before being erected in the road, they are submitted to a mechanical and electrical test. The former consists of bolting the insulator to a beam and leaving a weight of about 1 cwt. suspended to the pin for a certain time. If the pin remains rigid the insulator is taken to a sub-station to undergo the electrical test, which is effected by first immersing it in water and then placing it with a number of others upside down in tanks of water to half the height of the casting, and connecting the pins in circuit with a pressure of 2,000 volts. Should no leakage occur after 15 minutes, the insulators are considered fit for use.

Cable Connectors.—(Figs. 8 and 9, Plate 1.) These consist of brass castings riveted to the stalks of the conductor bars with two copper rivets, and to which are bolted the lugs of the cables.

The connectors now in use are 2 inches longer than those formerly employed. This increase in length was found necessary for connecting and disconnecting the cable when the current was on the line. With the shorter type it was difficult to avoid short-circuiting by the box spanner coming in contact with the slot rail or insulator casting.

SPECIAL WORK; CROSSOVERS AND JUNCTIONS &c.

Crossovers.—These are placed at intervals to permit cars being transferred from one track to the other. They are similar in construction to those originally used, and are made in massive separate parts, which can be divided into special yokes, and top castings. (Figs. 30 to 32, Plate 6).

The yokes, spaced 4 feet 6 inches apart, are of cast-iron with machined bolting-up faces, and are considerably heavier in section than the ordinary yokes. A special large casting is arranged centrally at the point where the two conduits divide, and is bolted to the inside bottom flange of the two yokes, forming a dividing wall known as a gusset post. The two castings containing the movable point tongues are bolted in position on the arms of the first two yokes.

The rest of the special castings are bolted on, forming, when assembled, two complete tracks, one branching off from the other, and thus making one end of a crossover, the other end being a duplicate, and joining up in the clear way. The crossover is about 60 feet from toe of point casting to toe of point casting, and the one track leaves the other at a radius of 100 feet.

The concrete conduit is formed and the conductor bar work is installed, in the way already described, cable being provided to bridge the physical breaks.

Extensions of the point mechanism to the footpath (Figs. 33 and 34, Plate 6), and water boxes (Fig. 18, Plate 3), are now only provided at terminal crossovers, and facing points of junctions.

The mechanism for actuating the points has been slightly modified and strengthened. The slot tongues being connected to their corresponding point tongues, are in turn connected by two vertical bars dropping down clear of the conduit and riveted to a horizontal bar, gussets being riveted at the angles for rigidity. The modified design has had the effect of eliminating a number of the original pin joints, thus decreasing the risk of lost motion due to wear at such points.

Junctions are built up in the same way as crossovers, and the mechanism is precisely similar.

Twin Slot.—Twin slot (Fig. 37, Plate 7) is adopted when the road is not wide enough for a double track. The two tracks have track rails in common, but instead of one slot converging into the other a second conduit is carried along parallel to it. This, beyond simplifying the slot point construction, has practically no advantages over the single line method of construction, and has the great disadvantage that should it be necessary to run a car backwards and the track points happen to be set against its returning to the line it has just left, the plough would follow the conduit of one track whilst the car might run on to the other track, thus separating the car and the plough.

SIDE SLOT SYSTEM.

An alternative method of construction is in operation, viz., the side slot system, of which only a very short length has been constructed in London. It has been in operation in Bournemouth since 1903, and although slightly cheaper to construct, has not,

in certain other respects, been entirely satisfactory. One of the slot rails forms the head of the running rail and the other forms the lip or cheek. The wear round curves with heavy traffic is found to increase the width of the slot to such an extent as to be rather dangerous to ordinary traffic, and for that reason the system may not be generally adopted in London, where the traffic conditions are very severe, the length of line laid down being regarded as an experiment.

ELECTRICAL DISTRIBUTION.

Electrical energy for driving the cars of the London County Council Tramways is generated at Greenwich, in a new station, of a present capacity of some 20,000 H.P. It is generated at a pressure of 6,600 volts alternating current, and at that pressure is transmitted, by means of copper cables, to various sub-stations, each of which feeds a separate district. Power was originally obtained from various Electric Supply Companies, and later from the Council's own, with Supply Companies' plant, but now the whole energy is derived from Greenwich, power being taken from one company only on occasions of overload.

The second section of the Greenwich Generating Station is now under construction, and, when completed, about 50,000 H.P. will be available.

Sub-station Conversion, &c.—The current, on being received at a sub-station, is converted from alternating to continuous current at a pressure of 550 volts, by motor generators (synchronous and asynchronous) the motors of which are driven by the alternating current received from Greenwich, and in turn the motor generators transmit the energy at continuous current to the different feeding points in each district, there being a feeding point to every half mile section.

Continuous current is used on the lines in preference to alternating, as, amongst other advantages, it is easier to control, and, being at a much lower pressure, is less liable to break down insulation and leak away, although, when testing the conductor bar work for insulation, &c., a pressure of 2,000 volts alternating is used as a precaution against weak points.

The current, on being received from the Central Power Station, is controlled by a switch-board consisting mainly of three parts, each made up of a number of slate or marble panels.

One part receives the high tension current from Greenwich, and, through its necessary switches, meters, &c., passes it on to the motor generator. Another part receives it from the generator, through switches, and transmits it through an automatic cut out, ammeter and voltmeter, to two copper bus bars running the length of the switch-board. The third part consists of the feeder panels, which collect the current from the bars and distribute it through necessary meters and switches to the feeder cables, and these carry it to the feeding points.

Automatic Circuit Breaker.—Each feeder panel and dynamo panel has an automatic switch forming a circuit breaker, which performs a similar function to that of a safety valve on a steam engine, its object being the safety of the dynamos, cables, switch gear, &c. For instance, should an excess of current pass through the cables from the dynamos, which might happen from an unduly heavy working load being suddenly thrown on the dynamos, or should a bad leak arise, which would also put a heavy load on the dynamos, if there were no circuit breaker, the cables, being insufficient to carry the load, might melt, the dynamo would spark and flash badly, which would damage the brush gear, &c., and in the event of a dead short-circuit, might burn the armature of the dynamo right out and wreck the board.

The object of an automatic circuit breaker is to open the circuit between the fault and source of supply, an operation which is effected by various contrivances, a satisfactory type being a magnetic blow out. The switch maintains contact mechanically. The lever which holds the contacts together, is kept up by means of a toggle, directly underneath which a magnetic coil is placed and connected in series with the main circuit. When the current is normal the magnetic coil is not strong enough to attract the solenoid core up and open the switch, but as the current rises on the main circuit and thus through the coil, the weight of the core is overcome, and, being drawn up, trips the toggle. The switch opens, and the circuit is broken, and simultaneously the arc set up is destroyed by the magnetic flux. An electric alarm which is usually attached, attracts the observation of the switchboard attendant.

Reversible Polarity.—A point of interest about the main L.T. switches on these feeder panels is that the polarity can be reversed on the feeders at will. This is done by having a double

set of jaws, two at the top and two at the bottom ; the blade of each switch being pivoted between the upper and lower jaws. The cables carrying the current from the bus bars to the feeder panels are connected to these jaws. The normal position is to have the switch blades in the top contacts. This makes a given conductor bar in the conduit positive and the other negative. If an earth develops on the positive the switch blades are put into the bottom jaws. The connections are so arranged that this operation reverses the polarity of the conductor bars in the conduit, thus putting the fault on the negative which is earthed in the sub-station. The fault is then corrected as soon as traffic permits.

Feeding.—The feeder cables on leaving the L.T. feeder panels are joined up to other lead-covered cables, which are drawn through earthenware pipes to the various feeding points every half mile along the routes.

Brick pits are built at intervals of about 100 yards for convenience of pulling these cables into the pipes, and for making the joints.

The feeding points terminate in cast-iron feeder pillars erected on the footpaths. Each of these pillars, to which there is a door, back and front, contains a miniature switch-board (Fig. 21, Plate 4), consisting of two slate slabs, each of which has in front four switches, their jaws and blades being connected through holes in the slate to terminal studs at the back.

The two feeder cables are drawn up into this pillar, the positive one being bolted on to the stud of the switch blades of the top or positive panel, and the negative connected to the stud of the switch blades on the bottom or negative panel, the four blades being connected to their feeder cable by copper strips.

Four distributing cables are taken through earthenware pipes, one from each jaw of the four switches on the top panel through a cable pit (Figs. 19 and 20, Plate 4), to the positive conductor bars in the two tracks, each side of the break forming the section insulator, which has already been mentioned, and four distributing cables are taken one from each of the four switches on the lower panel, to the negative conductor bars in the same way.

It will now be seen that should it be necessary to cut off the current from any half mile section, it can be done by drawing

the switches in the pillars at either end of the section, thus isolating the line from the feeder cables.

It is possible at the same time, should necessity arise, to cut out the feeders in each pillar by disconnecting the copper strips from them and bolting them together, and thus bridging the gaps at the section insulator, and making one feeder pillar feed two sections instead of one section, the intermediate pillar merely acting as a connecting link. This is done when any feeder has to be thrown dead, either for repairing faults or other reasons.

In each of these pillars telephones are provided communicating with the sub-stations feeding each district. A special telephone has lately been added to all tramway termini which enables the inspectors and controllers to communicate with their head offices, and officials at the head offices can also communicate with the termini, a loud gong sounding in the pillar to attract the attention of the inspectors in charge.

COLLECTION OF CURRENT.

Plough.—The current is transferred from the conductor bars to the motors on the cars by means of a collecting device called a plough (Plate 2), which is suspended on two horizontal bars or slides fixed to the car truck, and is free to traverse the entire width of the car.

The plough consists of a main body of a rubber composite material, through which the two insulated leads pass, terminating in two rubbing surfaces, one on either side of the body, called shoes. These are made of cast-iron, and are attached to the main body by means of springs and links, and the former, when fully expanded, leave the two surfaces 7 inches to 7½ inches apart.

When the plough hangs in position between the conductor bars, each spring has to be compressed half an inch, thus keeping the rubbing surfaces of the shoes pressing against the two conductor bars. The actual connection between the motor leads and the shoe is made by a small flexible conductor, which on occasion, acts as a fuse.

Current on reaching the car passes through automatic cut-outs to the controller on the driver's platform, whence it is transmitted through a series of resistances to the terminals of the motor, and

which resistance the driver cuts out when starting up the car from rest.

INSERTION OF JUNCTIONS, &c., DURING RECONSTRUCTION.

Having described the past and present methods of construction of the conduit system, some reference to the difficulties to be overcome during reconstruction when inserting junctions, &c., into existing electric conduit lines, carried out whilst the car service is maintained, may be of interest. Such work is accomplished in the following manner:—

The line is first thrown dead; the conductor bars are removed, and the old conduit and track foundations broken out, cars being run over the existing rails, which are packed up temporarily for the purpose. Traffic is suspended for a few hours during one night to enable the old ironwork to be replaced by new which is packed up in the same manner, to allow the cars to run until it is possible to suspend traffic again for a short time, when the new conduit is formed and concrete foundations, &c., inserted. Traffic has once more to be suspended during the night in order that the conductor bars, jumpers, &c., can be replaced.

The difficulties of general construction work are greatly increased owing to the many obstructions which have to be encountered. Pipes, cables, &c., require to be diverted, on account of being laid at such shallow depth, before the conduit can be excavated or, as often happens, during its actual construction. Some of the most notable examples on the London lines occurred in Nine Elms Lane, where several large mains, including some 27 inches and 36 inches in diameter had to be diverted, in addition to sundry small pipes throughout the whole length.*

CONCLUSION.

The conduit system of tramway construction has been greatly criticised, chiefly, however, on account of its greater cost of construction and maintenance compared with that of the overhead system, but very little has been proved against it as regards its general efficiency in operating. It has many points to recommend it, amongst others, that it is much more

*The photographs exhibited illustrate some of the difficulties met with during the process of reconstruction.

sightly than the overhead system, there being no standards or overhead wires to disfigure the street, and when one considers the mass of such wires, &c., at an ordinary junction on the overhead system, one shudders to think what such crossings as the Elephant and Castle, St. George's Circus, or any similar district in London would be like with that system in vogue.

It has a possible rival in surface contact system. The London County Council are at present experimenting with a short length of the "G. B." (Griffiths Bedell) system, but it yet remains to be seen if this or any form of stud contact system, will prove satisfactory under the conditions met with in London, although a few miles are being operated in the provinces.

The comparative average cost of the Conduit, Surface Contact, and Overhead systems, is as follows, but it must of course be noted that in every system the cost of construction varies greatly, according to the nature of the obstructions and the extent of special work necessary :—

	per mile (single)
Conduit (including special work, pipe diversions, &c.)	£17,000
Surface Contact ,, ,, ,, ,,	£9,700
Overhead ,, ,, ,, ,,	£9,200

The first installation of tramways on the conduit system in London was carried out with Sir Alexander Kennedy (Past President of the Institution of Civil Engineers), as Consulting Engineer ; and since its completion the construction and conversion of the permanent way and roadway for the conduit system, and street improvements connected therewith, have been under the direction of the Chief Engineer to the London County Council, Mr. Maurice Fitzmaurice, C.M.G., M.Inst.C.E., M.A., &c., whilst the electrical equipment of power and sub-stations, together with feeding arrangements, have been supervised by the Chief Officer of Tramways, Mr. A. L. C. Fell, M.I.E.E., the buildings of the Central Power Station and sub-stations being designed by and built under the direction of, the Architect to the London County Council, Mr. W. E. Riley, M.Inst.C.E.

In conclusion, the Author desires to thank those who have kindly assisted him by lending the lantern slides and the photographs used in connection with the illustration of his paper.

Discussion.

Before the discussion was proceeded with, a number of excellent lantern slides were shown illustrating the process of construction which had been described, some of them indicating the great difficulties encountered through obstructions from pipes, &c.

MR. FITZ ROY ROOSE said he wished to express his thanks to the Secretary for reading his paper to the meeting. He might add a remark as to the way in which the rails were packed. The mixture of 6—1 concrete was only brought to within one inch of the underside of the rail, and when this had set, a fine mixture of 3—1 concrete was introduced and punned hard in with iron beaters, to ensure an absolutely sound and homogeneous bed.

MR. L. H. RUGG (Past-Chairman) proposed a vote of thanks to the author for his paper, and remarked that although he (Mr. Rugg) had little personal knowledge of the subject dealt with, he could say on behalf of all those present, and from his experience of papers read before the Institution, that the present one did very great credit to the author. He only regretted that so much valuable information had to be digested in the short time during which the paper was being read, and therefore ventured to suggest that it might be desirable to have printed copies of the papers available some time before the meetings, so that those desiring to take part in the discussions could come fully and thoroughly prepared. The Institution's Past-President, Sir A. B. W. Kennedy, had been referred to in the paper, and it was only fit and proper to recall that it was Sir Alexander who had been bold enough to recommend the conduit system in the teeth of a good deal of opposition, and that it was he therefore who deserved credit for the great success which all agreed the system had proved to be. It was certainly one of which the greatest city in the world might well be proud.

Mr. Rugg considered that tramways of the conduit system only, should be used in London, and in conclusion, asked the author if he would explain the difference between the earliest systems of conduit construction and that adopted by the London County Council; and also the method of steel centering referred to in laying the concrete for the conduit.

MR. F. D. G. NAPIER (Member of Council) seconded the vote of thanks, and expressed his regret that Mr. F. S. Pilling (Vice-Chairman), with his special knowledge of tramway construction, was not present that evening to take part in the discussion. It was interesting to observe that, while the London County Council had abandoned rivets for their track rails joints, the Middlesex Council were adopting them in preference to bolts; he believed that if the riveting were well done, a very satisfactory joint could be obtained. He asked for the author's opinion of welded joints, and whether they were used at all on the construction under review. Referring to the insulators described, it would be of value to know what the particular composition of the cement was in which they were embedded, as the satisfactory fixing of bolts in porcelain was not an easy matter.

At the conclusion of his paper the author had made some disparaging remarks in regard to the overhead system, which could not be allowed to pass unchallenged. He (Mr. Napier) considered that the overhead system was certainly quite as reliable as the conduit, and the objection to standards was a very slight one. They could be utilised for the public lamps, or the span wires could be supported from the buildings, as was done in some of the provincial cities. A very serious drawback to the conduit system of construction was the large amount of iron-work in the roadway, which was always a source of much annoyance to the other users of the highway. It should also be remembered that the overhead system was not so likely to be disabled by snow or floods, both of which had very fatal effects in the conduit system. Surely the author was not serious when he advanced the plea of sightliness, as he could hardly consider the architectural features of the Borough or Whitechapel Road so imposing as to be marred by overhead wires. In the recently published London County Council tramway accounts, the annual debt charges were shown to be nearly £1,000 per route mile higher than they would have been if the overhead system had been adopted, and there was no doubt that when future extensions had to be made in the less densely populated districts, the fares would either have to be increased in comparison with those ruling at present, or some less expensive system introduced.

The author's opinion as to the advisability of fitting overload circuit breakers on both machines and feeders, as described,

would be valued. The speaker's own experience had shown that a bad short circuit on a feeder would trip not only the feeder-breaker but also the machine, so shutting down circuits needlessly; he therefore preferred overload switch only on feeders, and an automatic reverse circuit breaker on the machines.

Further, the magnetic blow-out switch mentioned seemed to be giving way to the switch fitted with carbon tips on which the circuit was finally broken.

The photographs exhibited of the places where special work had to be done in the construction of the London tramways, while showing very clearly the immense difficulties overcome by the able engineers who were responsible for the tramways, also showed how badly the conduit system was suited for a city with so many existing obstructions in the roadway.

MR. H. C. KING (Visitor) drew the attention of the meeting to a model illustrating the construction of improved conduit points which he had devised. The invention related to tramways working on the conduit system and to the means employed for guiding the plough in the conduit from one slot into another at a junction. In an electric conduit system the plough was at a junction usually guided by means of two trailing switches which were pivoted in the casting just ahead of the junction of the two slots, as illustrated in Fig. 31, Plate 6, of the drawings accompanying Mr. Roose's paper, and one or other of these switches was moved into the slot so as to guide the approaching plough in one direction or the other.

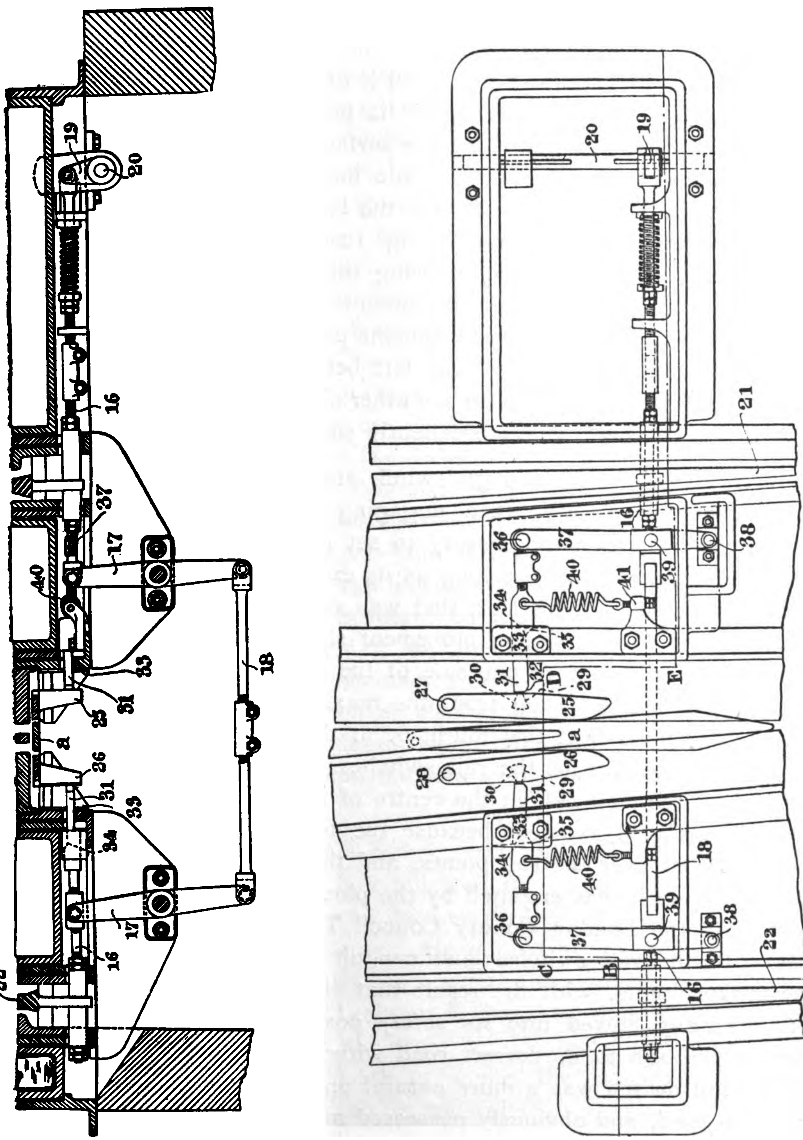
It was, however, found in practice with the trailing type of switches, that in the event of mud or other impediment becoming deposited behind the rail switches in the grooves, decreased movement resulted, causing a decreased movement to the simultaneously operated conduit switch or switches, and as the movements of the latter were greater than the movements of the rail switches, any decreasing movement of the latter was multiplied in the former. Accumulation of mud and the like, frequently resulted in the conduit switch or switches not being moved sufficiently across the slot, with the consequence that the angular point of the casting at the junction of the slots (the overhung slot point) was exposed in the path of the plough, which, on striking it, was apt to be broken. Cases of this kind occurred

and caused much delay in traffic on a busy road. The liability of the plough or overhung slot point being damaged under the usual circumstances was also present if by chance the rail switches were only moved part way through carelessness.

The object of the new device was to avoid the liability of the plough meeting the overhung slot point casting at the junction of the conduit slots, or fouling when the rail switches were out of their proper position, and to thereby prevent damage to the plough as above described. The device consisted in so adapting the facing switch that a considerable range of movement, in excess of that which was absolutely necessary for the correct guidance of the plough, was permissible, so that in the event of the switch not being moved to the full extent, the plough would be free to meet the switch and complete its movement, thereby ensuring correct guidance.

The accompanying drawing illustrated the mechanism, a set of which had been installed for some six months on the London County Council Tramways at the Clapham Car Shed, Clapham Park Road, and had been in daily operation during that period. The facing switch *a* was moved by lever arms 25 and 26, pivoted respectively at the points 27 and 28, each lever carrying on its lower side a projecting lug, 29, the face, 30, of which was formed obliquely, as shown. The outer side of each lug, 29, lay against the end of a bolt or rod, 31, a portion of the end face of which was sloped off, as at 32, for a purpose to be afterwards explained. The rod 31, worked in a guide 33, and a sloping shoulder 34, was formed on the rod 31, to engage a corresponding shoulder 35, in said guide. The end of the rod was connected at 36 to the outer end of lever 37, fulcrumed at 38 and actuated at 39 from the draw rod 16, connected to both levers 37. The draw rod was connected at one end to a crank 19, which was adapted to be operated by a hand lever in the usual way in order to set the rail switches 21 and 22, to which the draw rod 16 was also connected.

The operation of the gear was as follows:—The draw rod, when actuated, operated the two rail switches, and the levers 37, moving them in the same direction. One of the rods, 31, would then be pushed inward and the other outward. The end face of the inward moving one, butting against the projections 29, would push forward its corresponding lever 25, and would thus move



NEW DESIGN OF CONDUIT POINTS.

the facing-switch *a*. The lever 26, on the other side, would be correspondingly moved to accommodate the movement of the switch *a*. As the rod 31 advanced, the co-operation of the cam or sloping surfaces 34 and 35 caused it to move laterally (against the action of the spring 40) upon its pivot 36, so that its free end was gradually shifted along the surface of lug 29, till the two oblique surfaces 30 and 32 came into line. Thereby the further movement of 31 no longer affected the lever 25, which would be now stationary, its free end having reached one side of the conduit slot, and its movement being thus stopped to prevent it projecting into and fouling the conduit slot. In the meantime the lever 26 was pushed over when the plough came into contact with the switch *a*. Space was left between push rod 31 and lever 26, to allow clearance for the other side of the facing switch, when its movement was subsequently completed by the plough.

By first setting the plough switch and making it of such a form that the plough when engaging it could complete its movement, it was not necessary to set it in any one particular position. For instance, as long as its extreme point was on one side of the centre of the slot, that was sufficient, but it was preferred that the maximum movement should carry the point a considerable distance to one side of the slot. This large range offered possible deviation from the maximum compensation for any loss of movement that might occur through mud, &c., limiting the movements of the rail switches. If by any chance the plough switch were left in the centre of the slot, damage to the plough was still avoided, because the fore-wheels of the car would thrust over the rail points, and thereby move the plough switch before it was engaged by the plough. This was actually tested on the London County Council Tramways by running a car with the rail switches and conduit switch placed in their central positions, with the result that the conduit switch was automatically moved into its safety position and the plough passed through to its correct road without damage. This type of conduit switch was a more natural one than the trailing type hitherto used, and obviously possessed many advantages.

MR. W. H. DE RITTER (Member) heartily supported the vote of thanks to the author. The paper was to any engineer and also to any layman, an excellent piece of education. The difficulties

due to alterations and diversions of large mains, pipes, &c., necessitated by the conduit system, and so well illustrated by the photographs exhibited, would appeal to ratepayers who could now well understand where much of the heavy expense was incurred. In the East London district the 48 inch mains of the Gas Light and Coke Company were laid almost in the centre of the road, and therefore had to be lowered and diverted, involving engineering problems requiring great care and skill to deal with; lengths of about 200 feet being worked upon without interrupting the gas supply. It was satisfactory to know that such a powerful body as the London County Council, and one possessed of adequate funds, was experimenting with other systems of traction. One could not help feeling that in the interests of the public such bodies should encourage and help inventors to perfect systems which were likely to prove advantageous financially. Mr. De Ritter made reference to the paper read by Mr. A. L. C. Fell before the Municipal Tramways Association on "Rail Corrugations," and reported, with discussion, in "The Tramway and Railway World" of October, 1907. Troubles from rail corrugations had occurred on the Southern lines, but were absent on the Northern. Could the author explain the reason? Mr. Fell stated that a special car, fitted with a grinding machine, was put into operation on the Southern lines. The speaker also asked why so much trouble was experienced at Aldgate where frequently the cars were stopped, all lights out, and the cars had to be moved forward by pinch bars.

Mr. C. Singleton (Member), after referring to the great interest with which he had followed the paper, asked whether the negative conductor was dead-earthed at the sub-stations, or earthed through a resistance. He quoted his experience on the Hammersmith and City Railway, where the negative was earthed through a resistance of about 6 ohms. to show that such an arrangement allowed of the train service being continued with a bad enough positive earth to make the potential between negative and earth as much as 300 volts for long periods. He also asked whether the overload circuit-breakers on the machines and feeders were fitted with time-limit devices.

He had had the opportunity last winter of seeing the tram-

ways in Berlin, where there was a short length, perhaps two miles, of side-slot conduit construction, working conjointly with the overhead system. Frequent delays were caused there by the ploughs refusing to enter the slot, and having to be forced down with crowbars. It was also quite usual to see one car with a disabled plough being pushed by the succeeding car, and when, as was often the case, both cars had trailers, and the pushing car got stuck on a dead point at a junction, the driver of the next car arriving probably opened his circuit-breaker in the attempt to start five cars at once. He had several times seen cars coasting over a dead section of perhaps a hundred yards with the lights out. His last recollection of Berlin was of the Potsdamer Platz, where the men were at work with tower waggons, erecting an overhead wire to replace the conduit. He wished to explain that the particular interest of this lay in the fact that it was proposed to work the conduit system conjointly with the "G. B." surface contact system in Mile End Road.

The only serious accident of which he had heard, distinctly traceable to the use of the conduit system, was told him by an eye-witness. A child was bowling an iron hoop which fell down the slot, and in attempting to pick it up the child was killed. He had also heard stories of carrier's vans going along with chains hanging down behind, producing shorts between the positive conductor rail and the slot rail, as the chain swung, but these may have been fabulous, and he therefore asked whether much trouble had really been experienced from such a cause.

MR. R. MARSHALL (Member) called attention to the gaps between the conductor rails at points and junctions, and asked what attempts had been made to overcome the extinction of the car lights caused by the plough crossing the gaps. He suggested that some contact device forward of the plough itself might be fitted, so as to pick up current for lighting before the plough left the conductor bars and broke the circuit.

MR. E. F. BOULT (Member) said that he had come to the meeting as a road user, hoping to get some really instructive figures, but found that the author in his anxiety to interest engineers, which he certainly had done, had neglected some important considerations affecting those concerned in ordinary motor vehicle traction, which he (Mr. Boult) felt that the Paper

should have taken into account. He made a pointed reference, from personal experience, to the inconvenience to which other road users were put by the protruding rails so often found on tramway systems, and concluded by asking the following questions:—(1) What improvements have been effected recently to cause more silent running of the cars, and to increase the stability of the tracks? (2) What is the relative cost of the side slot or slotted rail system, and its practicability with a view to doing away with the third central rails? (3) What are the author's views regarding the rights of other road users, and what is the London County Council doing with the object of causing them the minimum of inconvenience.

MR. ALEXANDER MILLAR (Visitor) observed that Mr. Rugg in advocating that only conduit tramways should be used in London, had gone a step further than Sir Alexander Kennedy, who in his report to the London County Council, recommended that the use of conduit tramways should be confined to the great central zone of London, where streets with numerous junctions and crossings of a complicated character were met with, and where a very considerable car service might be anticipated. For the outlying districts where the conditions were less complicated, Sir Alexander had recommended that the overhead system should be adopted.

There could be no doubt that the overhead method of construction was a most efficient system for tramway service, and he (Mr. Millar) thought there was no intention on the part of the author of the paper to suggest any reflections on that system.

Reference had been made by various speakers to breakdowns of ploughs, and it must be admitted that for a short period after the system was first opened there was considerable trouble due to this cause during the wet winter months. At that time the main body of the plough was made of wood, and had to be dipped at frequent intervals in an insulating compound similar to that used in Paris and elsewhere, where the same type of plough was in use. Had the Council imported trained men from the Paris depots, it is probable that successful running results equal to those of Paris would have been obtained from the start. As it was, however, the men employed had no special training, and, as a result of this, and of the very exceptionally wet weather

experienced during the period stated, a considerable number of plough failures occurred. He was glad to say, however, that since then the number of plough failures had not been large, and now, with the use of a modified plough body made of rubber compound, plough failures were rare occurrences. When a fault did occur on a plough, if it was on the positive side, the polarity of the sections could be reversed until the car involved had reached a car shed, where it could be withdrawn temporarily from the service, or a new plough could be introduced at a dead plough hatch.

Several speakers had referred to the inconvenience felt at junctions and crossings of special work, due to the want of continuity in the conductor bars. This matter had received attention, and a system had actually been devised for giving continuous power, but the County Council had not felt justified in incurring the considerable additional expenditure to overcome what was, after all, only a momentarily flickering of the lights at night.

The differences between the present system and the system originally laid down under Sir Alexander Kennedy were not very great, and consisted chiefly in the use of yokes with extended arms, and the adoption of fixed covers instead of movable covers at insulators. Regarding the former, it was an important alteration as regards maintenance facilities, as by means of these extended yokes new rails could be held securely down and brought quickly to proper position and level to replace worn rails.

Regarding the costs given at the end of the paper, he thought it would be found by the time the experimental line in Bow Road was finished, the cost of the surface contact work would come out nearer £11,000 per mile (single line) than £9,700 as stated in the paper.

Mr. Boult had made reference to the additional lines of metal formed in the street by the slot rails, and while he agreed that iron was not an ideal paving material, he could not regard seriously the suggestion Mr. Boult had put forward that the additional lines of metal rendered that part of the road unsuitable for other vehicles. He would merely remark, speaking as a frequent user of the electric cars, that it seemed to him that most of the vehicles on the road did get on the car lines, and when once there clung to them, even after they had been

repeatedly warned off by the gong of an approaching car. Such conduct did not lead to the belief that this part of the roadway was unpopular with the owners of vehicles.

Mr. Napier had asked the author why motor generators were used in the sub-stations instead of rotary converters. He (Mr. Millar) did not think that this question fell within the scope of the paper, but he might say that the obvious answer to such a question was that the Consulting Engineer and the responsible officials of the London County Council, considered motor generators the more suitable machines for the work.

MR. A. W. MARSHALL (Member) did not understand the object of the author's remarks relating to the adoption of continuous current in preference to alternating current. The latter could be quite easily controlled, and could be reduced to as low a voltage as desired by means of static transformers. He also asked for a further explanation of the paragraph relating to reversible polarity. The method was a very interesting one. Did the author mean that one conductor rail was made positive and the other negative as a return, or were the track rails relied upon as the return? With reference to the comparative costs of different systems given at the end of the paper, would the author state which particular surface contact system had been selected in the example given.

MR. C. H. SMITH (Hon. Librarian) said he would like to ask whether there was any fall given to the conduit, to facilitate the drainage of water and mud to the sumps, and if so, what was the gradient. The author had mentioned that the component parts of the insulators were assembled with neat cement. He (Mr. Smith) had always been accustomed to using some sulphur compound for this purpose, and would be glad to know exactly what kind of cement was used, and whether any trouble had been experienced with it. He presumed that the hard wood packing piece between the bolting-up faces of the extended yokes and the rails was to give a certain amount of cushioning and flexibility to the running rails; did it serve any other purpose? He thought that the introduction of the cover plate to insulator pits, in place of the surface-boxes, was an improvement of great importance, and remarked upon the enormous amount of surface work in connection with the conduit

system, and that this alteration would reduce it considerably. Although the insulators could not so readily be got at in case of breakdown, the chances of failure were greatly diminished by the better exclusion of water and dirt. The change would mean a considerable saving in maintenance. He also wished to know what type of cable was used for the 500 volt feeders; whether they were single conductor cables, concentric, or twin core; and what type of cable was used for making the connections from feeder pillars to conductor rails, and for the "jumper." He also referred to the diversion of pipes and other obstructions in the way of the conduit construction, and wished to know if the London County Council had power to compel the various undertakers to move their mains, even if it was against their interest to do so. Would the author also mention what special precautions had to be taken in paving the roadway, what materials were found to be most suitable, and what class of wood was used, when wood paving had to be laid.

MR. P. B. BROWN (Visitor) remarked that the paper under consideration was one of great interest, because it gave a record of the improvements to the permanent way suggested by the experience of three or four years' actual running of the London County Council conduit system of tramways. The comparison between the present method of construction and that described in Mr. Millar's paper given before the Institution of Civil Engineers in 1904, was of great value, and the author was to be complimented on having brought the matter forward in such a concise and clear manner. The modifications introduced could roughly be classified under three headings:—First, the introduction of extended yokes for supporting and anchoring the track rails; second, the removal of the cover boxes over the insulators; and third, increasing the width of the conduit.

Experience had proved that with the latest type of insulator there was very little likelihood of short circuiting due to failure of the insulators or to the accumulation of dirt, and it would be generally admitted that the removal of the objectionable loose covers from the paving must be a decided improvement to the road surface. The introduction of extended yokes and an increased number of anchor joints was an indication of the present line of thought with regard to track work. More and more

attention was being paid to the question of upkeep, and tramway engineers were beginning to realise that in laying down a new system it was wise to spend money in securing the very best class of permanent way and special work. By that means the cost of maintenance could be very appreciably reduced. Not only would the cost be reduced, but a more satisfactory job of the renewal work could be made. It was well known that renewals had to be carried out in a very hurried manner, and that cars often had to pass over the work before the new concrete had had time to properly set.

In considering tramway propositions a certain length of life of the whole system should be estimated for, and due allowance made for the cost of renewals that were sure to be required from time to time. This, unfortunately, had not always been done hitherto. The boilers, engines, dynamos, and other parts of the generating plant might safely be assumed to last from 20 to 30 years, but under heavy traffic conditions, such as was the case in London, it was pretty safe to assume that at any rate a large portion of the track work would be worn out in about four or five years. If a permanent foundation were provided in the first place and the surface work was of the highest quality, the extra cost involved was saved over and over again within the life of the system. It was noteworthy to find from the paper that the alterations to the original scheme as introduced by Sir Alexander Kennedy, were so few, and it testified to the great care and foresight exercised by him and the officials of the London County Council in the preparation of the designs. The speaker considered that Londoners might congratulate themselves that their present conduit system of tramways was second to none in the world.

THE CHAIRMAN having made some observations on the drainage of the conduit, put the vote of thanks to the meeting, and it was carried by acclamation.

Author's Reply to Discussion.

MR. ROOSE thanked the members for the way in which they had received and discussed his paper. Some of the questions which had been put during the course of the discussion Mr. Alexander Millar had kindly disposed of, so that it would not be necessary to refer to them again.

Mr. Rugg had asked for an explanation of the method of using the centering. It consisted simply of two iron sheets hinged at the bottom and pressed out to the contour of the yokes to support the concrete until it had set; thereafter the form collapsed by wrenching up a joint, thus enabling the form to be removed. With regard to the difference between the earliest forms of conduit construction and the system adopted by the London County Council, this would be rather too big a question to deal with in the time at disposal, as there had been so many systems of conduit tried at one time or another. Many had been unsatisfactory, and the construction had differed so greatly in details that to recount them would form a paper in itself. The author considered the present system embodied all the latest improvements, amongst which might be mentioned: rigidity of permanent way construction, improved drainage and trapping of conduits, improved method of conductor bar suspension and insulation, and method of collection.

In reply to Mr. Napier, welded joints had not been used on the London County Council tramways, and had never been specified for any of those contracts, although experiments had been carried carried out with them. With reference to the composition of the cement for assembling the insulators, Portland cement of a quick setting variety was used, the Red Tiers Brand of the Associated Portland Cement Co., giving satisfactory results. Great care was necessary in the filling. As to the advisability of fitting overload circuit breakers on machines, the author agreed with Mr. Napier that these were not altogether necessary.

The author was very much interested in Mr. King's description of his model illustrating the construction of conduit points, which he had devised and which were in operation at the Clapham Car Depôt.

He could hardly agree with Mr. De Ritter that rail corrugations had not occurred on the Northern lines; as a matter of fact they were more or less universally prevalent, but the reason they were much less prevalent on the Northern lines was doubtless due to the fact that those lines had only been opened very recently to traffic, and further, only new rolling stock had been used for the services.

In answer to Mr. C. Singleton, who had asked whether the negative conductor was dead earthed at the sub-stations or

through a resistance, the author said the negative side of the system was earthed through the usual leakage-indicating glow lamps at the sub-stations. Time limit devices were fitted on the circuit breakers. With regard to small chains, &c., getting down the slot and causing trouble, such cases had occurred, but very infrequently.

As to what improvements had been effected recently to cause more silent running of the cars, Mr. Boult would find on reference to the paper that the rails were anchored much more frequently than in the original construction, thus ensuring a more solid running surface. This, coupled with the possible improvement in the equipment of the cars, had, no doubt, tended to produce the result alluded to. There was very little difference between the side slot and centre slot systems, and the difference in cost was comparatively small. Dispensing with the central rails was certainly an advantage, but against this had to be taken into consideration certain disadvantages, some of which were mentioned in the paper. With regard to Mr. Boult's question as to the author's opinion of the rights of other road users, he ventured to think that this would be considered too general a question, and outside the scope of the discussion, the subject being the construction of the conduit system.

Mr. A. Marshall in his comments on the adoption of continuous current in preference to alternating had apparently overlooked the author's statement that three-phase alternating current was used in the sub-stations. To have transformed this down and used it direct on to the line would have necessitated too many complications in the way of conductors, &c. In regard to the reversible polarity, it should be said that the top and bottom pairs of contacts on the switch were cross connected, the switch being of the throw-over type, the current passing to the conductor bars through the blades. Thus the polarity was reversed by merely throwing the blades of the switch from the top set of contacts to the bottom. The ordinary track rails were in no case used for carrying current; the conductor bars in the conduit were both equally insulated, so that either could be positive or negative at will. The particular surface contact system selected in the example given of comparative costs was the "G.B." system, which might be regarded an average example of surface contact construction.

To Mr. Smith, who had asked whether any fall was given to the conduits to facilitate drainage, the author replied that the gradient of the roads was used as far as possible, but no artificial gradients were created, sumps being put in at the lowest points attainable. The wood packings under the rails were inserted to act as cushions. Regarding the form of cables used, the high tension feeders were 3-core lead covered, the low tension feeders were single conductor cables lead covered, and the distributors and jumpers were single conductor cables, with an insulation of vulcanized bitumen. Referring to pipe obstruction, the London County Council had Parliamentary powers to construct the conduit system of tramways which included power to divert any obstruction met with. The diversions were generally carried out in conjunction with the different authorities concerned. With reference to the paving, the author replied that 9 inches of concrete was generally used under the paving. Granite sets were the most suitable form of paving for the tramway area, but when silent paving was required (in front of churches, &c.), creasoted deal blocks were found most satisfactory.

In reply to the discussion at Birmingham, the author pointed out that the plough carried was fixed to the frame work of the bogey; the plough itself being hung on slides running the entire width of the car, leaving the plough free lateral play if necessary. The slot rails were always laid centrally round curves. Mr. Relton, in asking why an alternating current was not used, was possibly not aware that three-phase alternating current was used in the sub-stations. As to whether single phase alternating current would be an advantage over the continuous current for tramway operating he was not prepared to say; he would merely point out that it was not in use in this country. With reference to the suggestion that two ploughs should be used instead of one, experience had shown that this course was not advisable.

PLATE 1

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Fig. 5. P
used at J

ECTOR TO CONDUCTOR BARS.

Fig. 8. Plan.

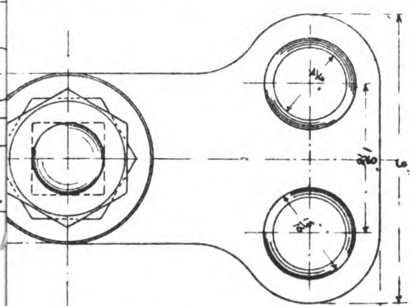
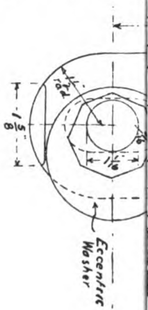


Fig. 6. Plan
Clip and Ec
adjusting gaug



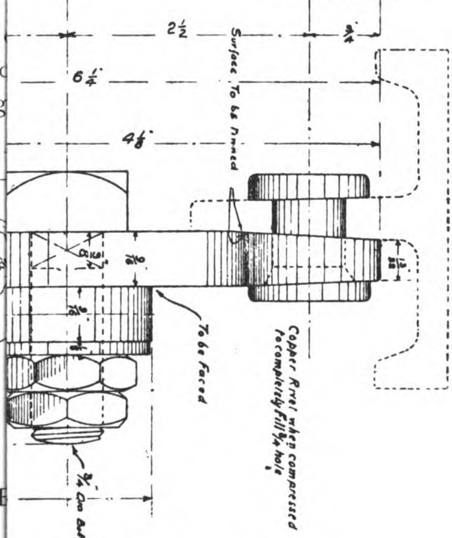


Fig. 7 F

9. Side Elevation.

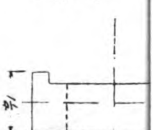


Fig. 12. Plan.

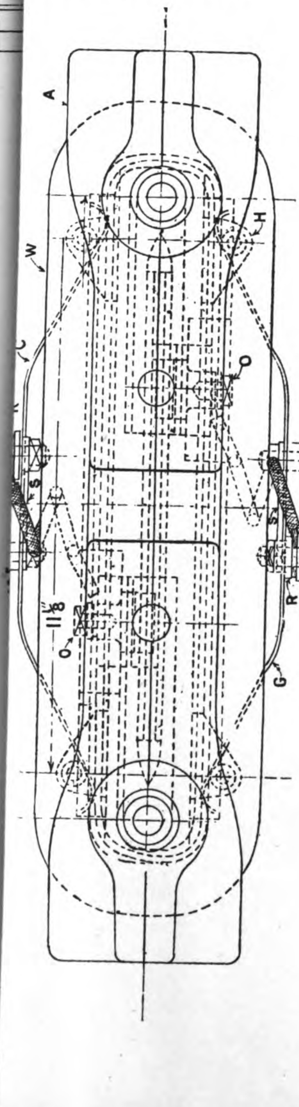
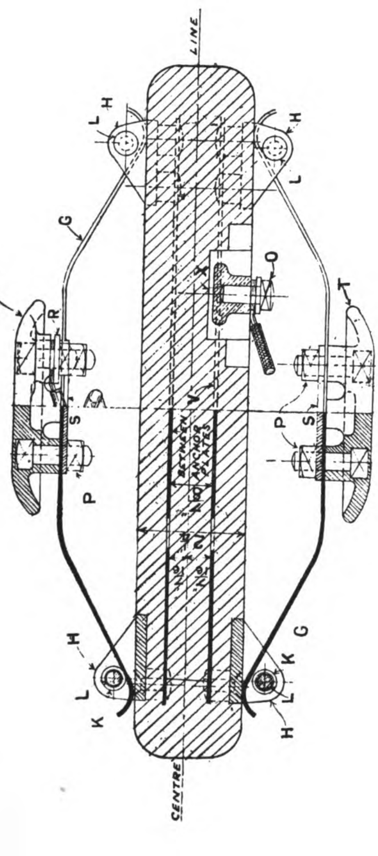
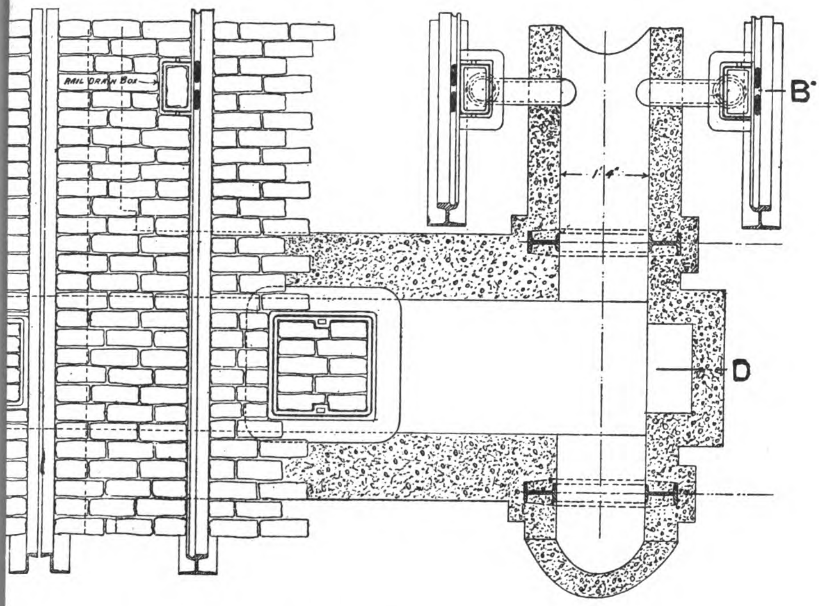


Fig. 13. Sectional Plan through **A B** (Fig. 10).



YSTEM OF ELECTRIC TRAMWAY CONSTRUCTION.

Fig. 16. Plan of Sump.



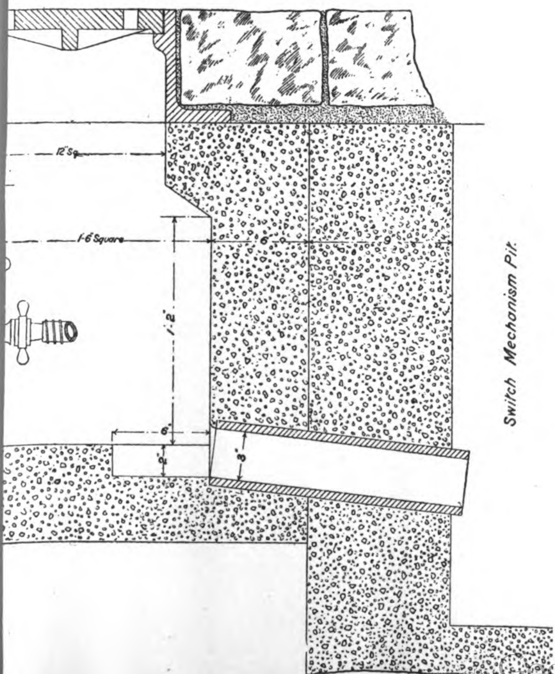
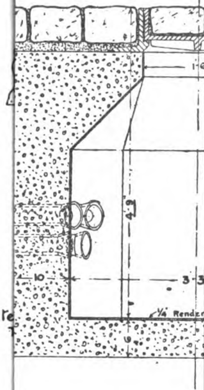


Fig. 18.
Water Box
for
Cleansing
Points.

OF ELECTRIC TRAMWAY
UCTION.

PLATE 4.

e Switch Board in
Pillar.



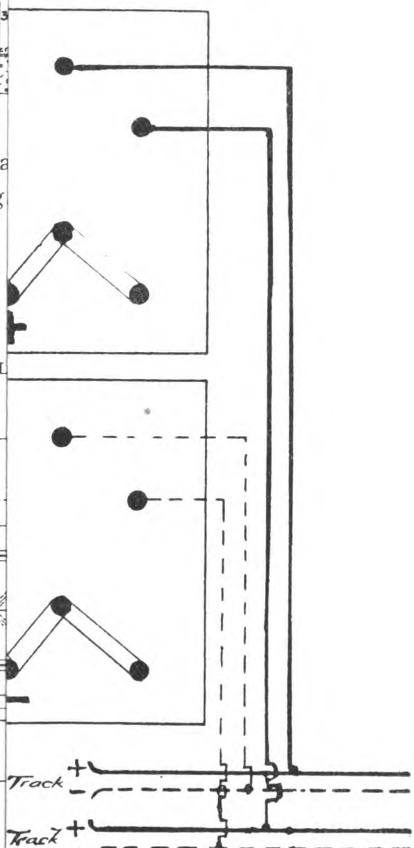


Fig. 19. Vertica
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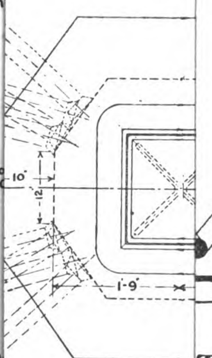

Fig. 20.

Short

II.

Ex

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RAMWAY

PLATE 5.

Fig. 27. Iron Hood.

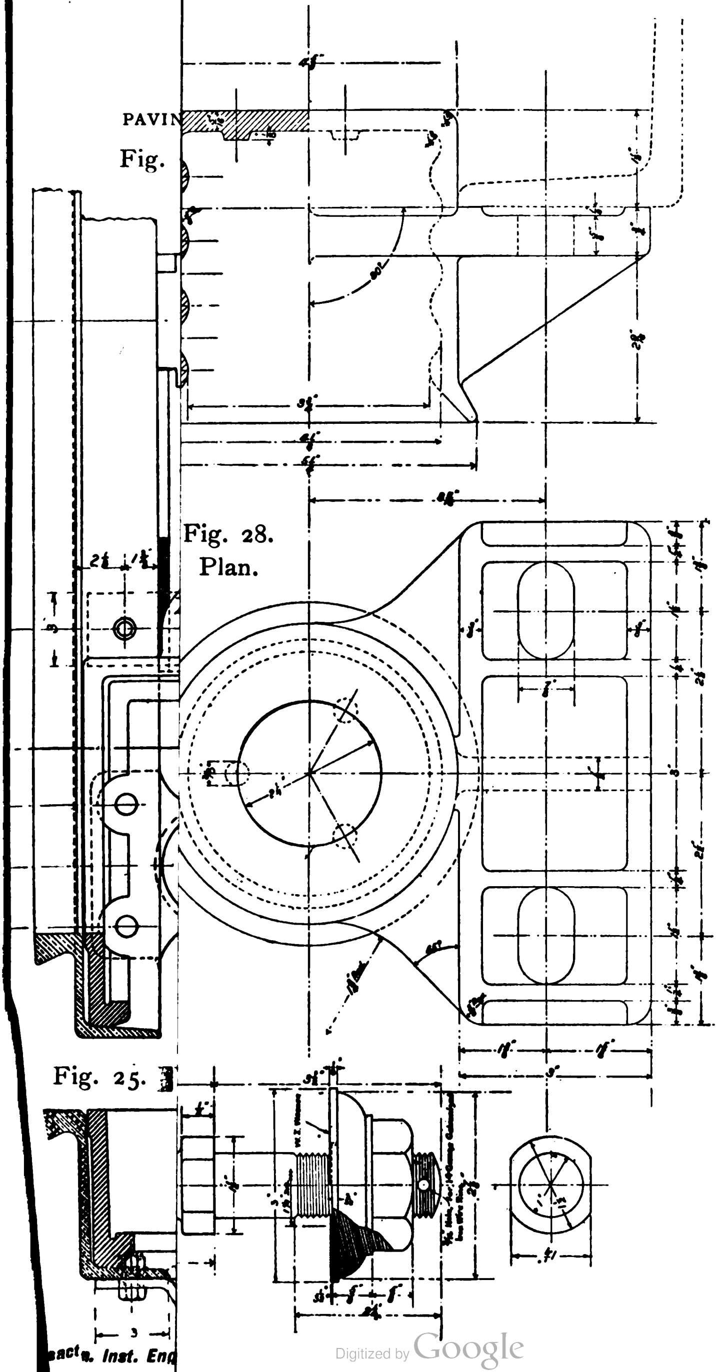


Fig.

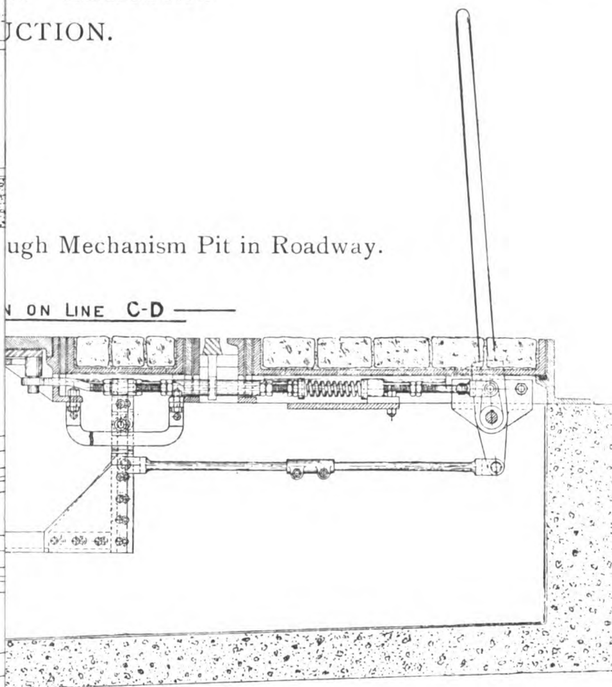
Fig. 28. Plan.

Fig. 25.

)F ELECTRIC
)CTION.

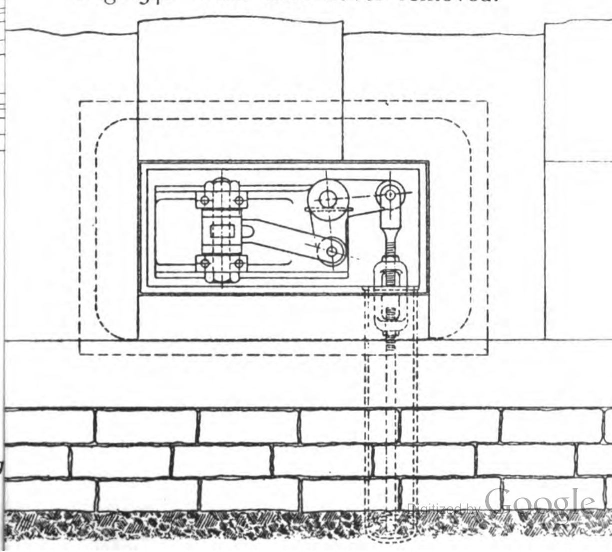
ugh Mechanism Pit in Roadway.

N ON LINE C-D



FOOTPATH.

Fig. 34. Plan with cover removed.



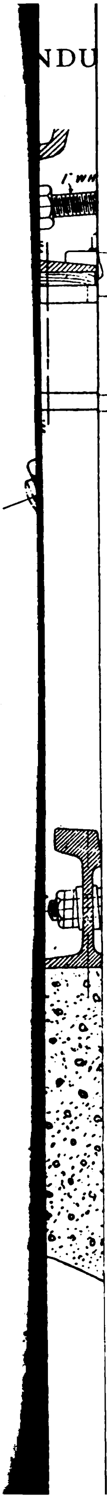


PLATE 7.

TRACK RAIL CLAMPS.

Fig. 38. Elevation.

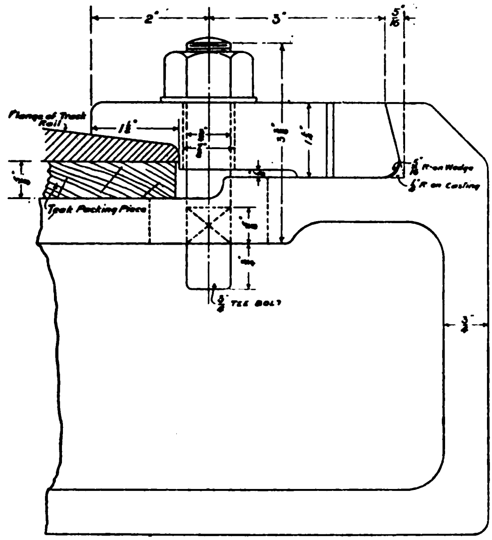
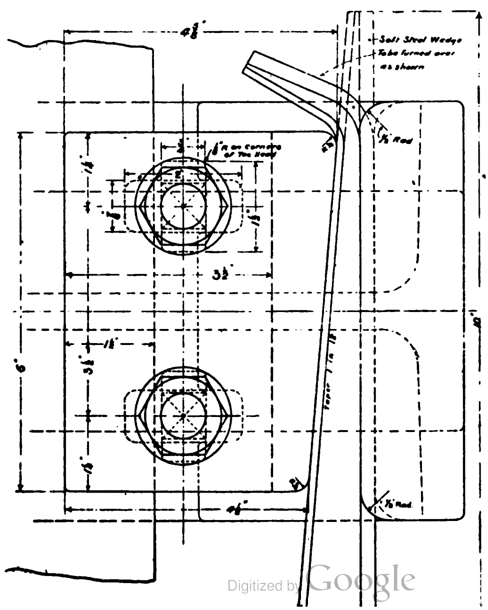


Fig. 39. Plan.



Part 6. MARCH, 1908. Vol. XVIII.

The Junior Institution of Engineers
(Incorporated).

President - - GUSTAVE CANET, M.INST.C.E.,
Past-President Institution of Civil Engineers of France.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

6th March, 1908.

ANNOUNCEMENTS.

NOTE.—To meet the wish of Mr. G. H. Hughes, author of the Paper on "The Purification of Water," announced for reading at the meeting on 13th March, Mr. Bullock is kindly completing his Paper for presentation then instead of on Tuesday, April 7th, to which date Mr. Hughes' Paper is postponed.

FRIDAY EVENING, 13th March. Meeting at 8 p.m., at the Royal United Service Institution, Whitehall, when a Paper on **"Automatic Fire Extinction as applied to Factories,"** will be read by MR. GEO. T. BULLOCK, A.I.E.E. (*Vice-Chairman*), Chief Surveyor to the Union Assurance Society.

SATURDAY AFTERNOON, 14th March, at 3 p.m. **Visit: The New General Post Office Buildings, Newgate Street,** by permission of the Postmaster-General, the Rt. Hon. Sydney Buxton, M.P., and under facilities afforded by the builders, Messrs. Holloway Brothers. Admission on production of Badge of Membership.

MONDAY EVENING, 16th March, at 6.30 p.m. **Demonstration of Automatic Fire Extinguishing Apparatus at** Messrs. Mather and Platt's Testing Station, Horseferry Road, Westminster. Assemble at Offices of Institution, 39 Victoria Street, at 6.25 p.m. Admission on production of Badge of Membership.

SATURDAY, 21st, and TUESDAY, 24th March. Messrs. Cordingley and Co. have kindly invited the Members to visit their **Annual International Exhibition of Motor Cars, Industrial**

Vehicles, Motor Boats, Motors, Accessories, Machine Tools, &c., to be open at the Agricultural Hall from 21st to 28th March. The tickets will only be available on Saturday, 21st, and Tuesday, 24th March, and application for them should be made to the Secretary of the Institution **not later than the 14th March.**

TUESDAY EVENING, 7th April. Meeting at 8 p.m., at the Royal United Service Institution, Whitehall, when a Paper on "**The Purification of Water**" will be read by MR. GEORGE H. HUGHES, M.I.Mech.E. (*Member of Council for Eastern Counties*).

Paper on "**Printing Machinery,**" Transactions, Vol. XVII., p. 329. Attention has quite recently been called to the fact that some of the illustrations in connection with this Paper are reproductions from the Proceedings of the Institution of Mechanical Engineers. We therefore gladly take this, the earliest possible opportunity, of acknowledging their source.

PAPERS FOR ENSUING SESSION. The Council desire to receive offers of Papers for reading during the ensuing Session. A special award is provided for authors under 21 years of age. Particulars of proposed papers should be sent in not later than the end of the present month.

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

CURRIE, JOHN HENRY; Engineering Department, Paddington Technical Institute, W.

HILLS, STANLEY MONCŒUR; Electrical Engineering Department, Northampton Institute, St. John Street, E.C.

JACKSON, CHARLES WARBURTON; Messrs. The Brush Electrical Engineering Company, Loughborough.

JEAVONS, ERNEST EDWIN; South Staffordshire Mond Gas Company, Tipton, Staffs.

MOLYNEUX, MORRIS JAMES HERVEY; South Metropolitan Electric Tramway and Lighting Company, Donnington House, Norfolk Street, Strand, London, W.C.

MULLARD, GEORGE EDWARD; Uttoxeter Rural District Council, Uttoxeter, Staffs.

TRUSTRUM, NORMAN SAMUEL; Engineering Department, Paddington Technical Institute, Saltram Crescent, W.

Proposed for election to the class of "Associate."

EARLE, JOHN FRANCIS; Mr. Thomas J. Digby, 32 Shaftesbury Avenue, W.

FISK, REGINALD JOHN; Mr. Walter H. DeRitter, Three Colt Street, Limehouse, E.

MAIDEN, EARL; Messrs. Strode and Company, 48 Osnaburgh Street, N.W.

STRODE, MAURICE; Mr. B. E. Dunbar Kilburn, Chancery Lane Station Chambers, High Holborn, W.C.

THARP, BERNARD SEYMOUR; Mr. Walter H. DeRitter, Three Colt Street, Limehouse, E.

LORD KELVIN.

We have received the following from Lady Kelvin:—

To the Junior Institution of Engineers:—

Lady Kelvin desires that the warmest thanks shall be expressed to all the many kind friends who have sent telegrams and letters so full of affectionate sympathy.

She feels deeply the world-wide interest and the appreciative tributes paid to the memory of her beloved husband, Lord Kelvin.

Lady Kelvin regrets that owing to her recent severe illness and the present state of her health, she is unable to write or attend to letters personally.

Netherhall, Largs, Ayrshire.

PERSONAL NOTES.

FRANCIS C. E. BURNETT wrote from Toronto, Ontario, Canada, 17th February, last, that he hopes shortly to send some observations on engineering matters there. He greatly enjoys reading accounts of other members' experiences in distant parts of the Empire and remarks that the "orange" monthly journal is always very welcome to at least one member in Canada.

E. HAY CURRIE wrote, on 27th January, from Mendoza, that since his arrival there he has been occupied principally in staking out centre lines for two branch railways in the vicinity of Mendoza and in preparing plans and sections for them. He has also carried out a large preliminary survey for another new branch. There is a good deal of work proceeding and every likelihood of its continuing for some years, but it is essential that men coming out should have a knowledge of Spanish, that being the universal language.

WM. N. GROUNDWATER writing (7th February) on board S.S. "Delhi,' of P. and O. Line, at sea nearing Colombo, reports that he has been transferred to that vessel, engaged on the China Mail

Service from Bombay to Shanghai, calling at Colombo, Penang, Singapore and Hong Kong. Although so far from headquarters he receives *The Journal*, forwarded to the different ports, and is thus kept informed of all the transactions of the Institution.

E. W. HOVENDEN has joined Matthews' Improved Electricity Meter, Ltd., 25 Bucklersbury, E.C., as Business Manager. Mr. Hovenden has obtained the London degree of B.Sc., and the Associateship of King's College, London.

L. M. JOCKEL has been admitted a Student of the Institution of Electrical Engineers and is now with the National Electric Construction Co., Ltd., Tramway and Electricity Works, Musselburgh, N.B.

F. TALFOURD JONES, Divisional Engineer, Bonny, Southern Nigeria, wrote on 7th February, that he would shortly be leaving for England, and that his address until further notice would be "St. Davids," Pembury, Kent.

H. BASSETT LOWKE has been appointed Assistant Engineer to Mr. E. Cooper Poole, A.M.I.C.E., Engineer to the Southampton Harbour Board.

HARRY LUPTON is expected home shortly, on leave, from the Straits Settlements, after six-and-a-half years service there.

J. B. MACFARLANE now acts as representative of Mr. R. Wolf, manufacturer of superheated steam locomobiles.

F. MEYER has removed his office from Nottingham to Central Chambers, 17a South Castle Street, Liverpool.

W. LANCELOT MOORE, after spending a few months at the British Aluminium Co.'s Works at Foyers, Scotland, commenced as Assistant Manager at their Norwegian Factory, Gjerde, Sendfjord, *via* Bergen, Norway, last November.

CHARLES E. OXBROW has been appointed Manager and Secretary to the Holyhead Waterworks Company, Stanley Street, Holyhead.

L. F. DE PEYRECAVE has taken over the management of the firm of Messrs. Thos. Evans and Son, Engineers and Boiler Makers, 32 North Street, Poplar, E.

F. S. PILLING has acquired the business of E. Finnemore, Lamp Manufacturer, 16a Summers Lane, Birmingham.

H. CARTWRIGHT REID, from the Admiralty Harbour Works, Malta, commenced his duties as Superintending Civil Engineer at Chatham Dockyard, on the 2nd March.

W. A. TOOKEY has removed his office from Westminster to 6 and 7 Grocers' Hall Court, Poultry, E.C.

EDWARD TREVENEN gives "Bush Tick Mine, Essexvale, Private Bag, Bulawayo, Rhodesia, S.A.," as his new address. The plant of the Red and White Rose Mine has been moved and re-erected there, and with additional plant is now equal to

thirty stamps (it was twenty previously) and is to be further increased to fifty in the course of the next few months.

W. GARNET WERNHAM has left Horsehay and is now with Messrs. Cockey and Son, Ltd., of Frome, Somerset.

GILBERT WHALLEY has entered the Drawing Office of Messrs. Robert Warner and Co., Walton-on-the-Naze.

CLIFFORD G. WILLIAMS has entered the service of The Trafford Power and Light Supply, Ltd., Manchester.

HAL WILLIAMS has arrived back in England after his visit to New Zealand.

Appointments.

220. Member, age 21, experience with Civil and Constructional Engineers, desires appointment as Assistant Draughtsman.

221. Member, Assoc.M.I.Mech.E., seeks appointment as Works Manager or Assistant; has held responsible positions. High-class interchangeable work a speciality.

222. Member, age 30, Mechanical Engineer; five years commercial experience; desires position as outside representative or assistant to principal or manager.

223. Member, age 29, is open to engagement as Assistant Engineer or Mechanical Draughtsman; four-and-a-half years in shops, two years in Technical College and six years drawing office experience in general engineering. Experienced in laying out of factories, millwork and cement machinery.

Changes of Address.

ANGWIN, A. S., 28 Park Street, Whiteinch, Glasgow.

BROWN, W. D., 32 Kelso Road, Clarendon Road, Leeds.

BREESE, A., 59 Cipping Street, Ardwick, Manchester.

EVANS, F. D., Public Works Department, Knala Lipis, Penang, Federated Malay States.

KENNEDY, W., Kangariibie, Mullion Creek, New South Wales, Australia.

NAIDU, R. N., Kathanoor, Mandiripalaiyam, P.O. (via) Palladam, Coembatore District, South India.

OXBROW, C. E., "Penybrin," Robert Street, Holyhead.

RISBOROUGH, E. J., 64 Ronver Road, Lee, S.E.

ROBUS, G. H., Norfolk House, Norfolk Street, Strand, W.C.

SHEPHARD, W. H., 53 Sotheby Road, Highbury, N., and 3 Crown Court Road, Old Broad Street, E.C.

TAYLOR, A. E., 74 Norfolk House Road, Streatham, S.W., and Messrs. Thomas and Sons, 3 Maiden Lane, E.C. [*5840 Bank.*]

WHALLEY, G., 37 Saville Street, Walton-on-the-Naze, Essex.

WILLIAMS, CLIFFORD G., 48 Westinghouse Road, Trafford Park, Manchester.

NOTES AND QUERIES.

8.—LUBRICATION OF GAS ENGINES.

J. P. HEWITT, Mount Road, Northland, Wellington, New Zealand, wishes to thank Mr. R. Marshall and Mr. F. L. de Peyrecave for their answers (page 22 *ante*) to his query at page 537 of Vol. XVII. of *The Journal*, as the result of which he has received from Messrs. Crossley Bros., particulars of an oil suitable for cylinders and bearings of large gas engines, which he has found to be less expensive than castor oil, a better lubricant, and easier to filter.

NOTES ON THE CALUMET AND HECLA MINE.*

BY ERNEST PENBERTHY (Member), of Painesdale, Mich., U.S.A.

(*Concluded from page 216.*)

Surface Equipment.—The surface equipment is notable for its completeness. With rare exceptions, everything is duplicated to prevent possible delays or suspension through fire or accident. The carpenters' shops are very large and fitted with every modern wood-working appliance. The extensive smithies, employing about one hundred hands, are supplied with numerous steam-hammers, forges, blowers, emery-wheels, drill sharpeners and various up-to-date appliances. In the Calumet smiths' shop are sharpened upwards of 50 tons of steel drills daily, requiring the services of a small regiment of drill boys for transport between the shops and mines.

The machine shop, covering an area of 225 feet by 250 feet, is very completely equipped, enabling an immense variety and quantity of work to be dealt with. The company have erected warehouses for general supplies, and for steel and iron, paints, &c., all having direct communication with the Hecla and Torch Lake Railroad, a private line (operated by the Company) that connects the mine mill and smelter by some 20 miles of main track, spurs, and sidings, reaching every shaft, shop, warehouse and mill. An iron foundry and pattern shop have just been completed and equipped with the most modern appliances.

The hoisting engines of the conglomerate mine are among the

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*In these Notes the writer, who is engaged with the Copper Range Consolidated Co., has made free use of the "Copper Handbook" by Horace Stevens.

most powerful in the world, ranging from 1,000 to 8,000 H.P. each.

At No. 4 Calumet, the brick engine-house, 62 feet by 146 feet, contains the 4,700 H.P. Corliss engine "Superior," with 40 inch cylinders and 72 inch stroke; the auxiliary engines, "Baraga" and "Rockland," of 2,000 and 600 H.P. respectively; two Rand air compressors of 25 and 40 drill capacity; and the "Machinac," a 7,000 H.P. quadruple cylinder triple expansion engine, operating three Nordberg air compressors, with a combined capacity of 500 drills. The Nordberg machines deliver the compressed and greatly heated air to a cylindrical steel cooler, 12 feet in diameter and 30 feet high, into which water is sprayed from above and drawn off at the bottom, this cooling the air to a temperature of 80 deg. Fah. (27 deg. Cent.). The hoist has four drums, each 8 feet 6 inches wide, and 20 feet 6 inches in diameter, operating four different shafts, two of the drums each carrying nearly 2 miles of steel cable. Steam is supplied by batteries of boilers in two boiler-houses, the adjoining brick chimney being 250 feet high, with inside diameter of 12 feet 6 inches. Locomotives haul the coal into the boiler-house, where it is fed to the grates by automatic stokers.

The Hecla engine-house, of brick, 47 feet by 80 feet, flanked by a large boiler-house, contains the 2,000 H.P. compound hoisting engine "Frontenac," and two auxiliary engines of 600 and 900 H.P., also a 30 drill Rand air compressor and a pair of water plunger air compressors with combined capacity of 144 drills, probably the largest machine of this type ever constructed.

Amongst the other important engine-houses is the one known locally as G. H. and S., from the initials of its three former engines, the "Gratiot," "Houghton" and "Seneca," of 2,000 H.P. each. The engine-house, operating Hecla Shafts 7 and 8, contains the engines "Hancock" and "Pewabic," each of 2,000 H.P., which operate 25 feet drums by spur gearing, and a 5,000 H.P. "Leavitt" engine for man cars. A 50 feet boiler house has ten boilers, and a 250 feet smoke stack of 12 feet 6 inches internal diameter. The engine-house serving shafts 9 and 10 contains smaller engines of from 1,000 H.P. downward.

Workmen's Houses, &c.—The Company owns about 1,200 houses, occupied by employees at an average rental of 5 per cent.

interest on actual cost, plus cost of maintenance. About 1,200 dwellings, are owned by employees on lands leased from the Company, at low yearly rentals. The Company maintains a large hotel and club-house for employees, and there is also a free library containing about 30,000 books, printed in a score of different languages, about thirty different nationalities being represented on the Company's pay-roll. There are some thirty churches on Calumet and Hecla lands, occupied by a dozen different denominations, and for all these churches, free sites were granted. Eight school-houses are provided, most of which were built by the Company. A hospital for employees solely was built in 1898, and is noted for the completeness of its surgical and laboratory apparatus. The staff consists of about twelve physicians. A benefit fund for sick and injured employees and bereaved families was instituted in 1877, and is managed by directors chosen by the workmen. Disbursements amount to about £12,000 annually; surplus monies have been invested in the Company's shares, bought on the open market, and have proved highly profitable. For the maintenance of the fund each employee pays 50 cents. monthly, and the Company adds an equal amount.

Water Works.—Three systems of water works are maintained, two at Calumet and one at Lake Linden. One of the former furnishes water from dams for fire protection, and the other pumps potable water four miles from Lake Superior, against a head of 600 feet, raising about four million gallons daily. At the dam and mine there are seven pumps, with a combined daily capacity of upwards of 45 million gallons. The Company maintains a fire department for protection of mine buildings, &c.; it also responds to calls from the town of Calumet, with a population of 40,000, that has grown up around this great mine.

Stamps.—The stamp mills are at Lake Linden, four miles from the mine, on a tract of 988 acres, which has several miles of frontage on Torch Lake. There are two mills—the "Calumet" and "Hecla," and a third is nearly completed, with which it is intended to re-work the sand (discarded in the early days) for copper. The "Calumet" and the "Hecla" mills each originally had eleven Leavitt steam stamps, with cylinders 14 inches and 21½ inches, and 24 inches stroke. To the southern end of the Hecla Mill has been added 165 feet by 308 feet of steel build-

ings by the American Bridge Company. Here are installed six stamps, each run by an independent 25 H.P. motor. Among its new features are seven Chilean regrinding mills (50 Chilean mills constructed by the Company are to be installed in the new mill for grinding the sand in Torch Lake), in addition to the old Averly grinders and enlarged finisher jigs. The new plant handles material with about 60 per cent. of the wash-water formerly required, thus effecting a double saving, inasmuch as all the water used in the mills must first be pumped in and thereafter raised as sludge water in the sand wheel.

The mills now contain 28 Leavitt stamps, 220 Wilfley concentrators, Woodbury-Benedict jigs, four-deck Evans-Rawlin's slime-tables, of which there are ten auxiliary to each stamp, Chilean regrinding mills and classifiers. A Robin's belt conveyor is used in the Calumet mill for carrying barrel copper from the heads. The mill has one "Nordberg" steeple-compound head worked with steam fed from a separate boiler. Water is supplied to the mills by five pumps, of which the "Michigan" is believed to be the most powerful in the world, having a daily capacity of 60 million gallons. The daily capacity of the engines "Huron" and "Ontario" is 20 million gallons each; of the "Erie," 10 million gallons, and an I. P. Morris pump can raise 22 million gallons daily.

Sand Wheels.—The material entering the mills as conglomerate rock leaves as coarse sand to the extent of 6,000 tons daily. There are five sand wheels ranging from 40 feet to 64 feet in diameter. They somewhat resemble gigantic bicycle wheels fitted with spur gearing instead of rubber tyres. The complete 64 feet wheel weighs 500 tons, and is mounted upon massive concrete masonry. Four 25 ton iron bed plates support the pillars carrying the 21 ton Krupp forged steel axle, which is 27 feet long and 32 inches in diameter, with a hollow core of 26 inches in diameter. Radiating from the axle to the rim are 2 inch steel spokes, 32 feet long. The rim is in twenty segments, weighing 10,700 lbs. each, the inner periphery of the wheel having 550 buckets in pairs, each 3 feet wide, and 4 feet 6 inches long, and holding 100 gallons, giving the wheel a capacity of 55,000 gallons per revolution. The wheel is 10 feet wide, and is driven electrically, 700 H.P. being required. Two years were occupied in building the wheel.

It is stated that the Company has 30 million tons of sand to re-work, containing 4 per cent. and 1 per cent. of copper. At the close of 1905 the rock production was 6,600 tons daily, and in 1901 the cost of producing 1 lb. of copper was 11 cents.; in 1905 7 cents.; and at the present time about 9 cents. It was said that the output in 1906 should for the first time exceed 100,000,000 lbs., leaving Anaconda as the only competitor.

FROM THE STARTING PLATFORM.

THE ARCHITECT AND ENGINEER ASSOCIATED.

Since the first joint meeting (ten years ago) with our friends of the Architectural Association, an endeavour has been made to bring them in closer touch with members of our own Institution by the reading of papers and the arrangement of joint visits. These efforts have met with some success, and should be encouraged. The recent paper by Mr. Waldram regarding the relationship of the architect and engineer should stimulate members of both professions to overcome the difficulties in the way of collaboration.

What is the province of the architect? It is to plan a building with convenient accommodation for a definite purpose, artistically treated in its design, and so marked as to give expression to the purpose for which it is being erected. In effecting this, he will devote the utmost care in selecting the most suitable and reliable materials known on the market, and adopt the methods of construction best suited for the structure.

In the present day when buildings of huge proportions are being erected, involving the use of a skeleton steel frame, and sometimes ferro-concrete, the assistance of the engineer will at once be needed, and it is for the latter to so design his part of the structure that, while observing utility and economy, he does not seriously prejudice the design of the architect. In making any observations, he should bear in mind that the building has to be constructed to meet the requirements of the various Acts of Parliament and Bye-laws of local authorities, and to preserve the rights and privileges of adjoining owners. For these various reasons, during the preparation of the drawings, it is advisable

that architect and engineer should consider all points and act in concert to obtain the desired ends.

In the preparation of his scheme the architect will have to resort to the engineer on matters relating to lighting, heating and ventilation, so that the necessary steps can be taken for the introduction of any special fittings and plant without interfering later on with the structure or its artistic treatment.

The foregoing remarks apply more particularly to buildings, such as, hotels, residential flats, hospitals, asylums, workhouses and schools, where decision as to the plans should be left to the architect.

In the design of commercial premises, such as breweries, distilleries, soap works, electric generating stations and factories, his position will be somewhat different. In these cases, he must study the special requirements of the engineer with regard to the accommodation of the machinery and plant for which the buildings are primarily intended, and he will find it desirable to acquire a general knowledge of the business or trade to be carried on, and so, be enabled to arrange his buildings to allow of the work being dealt with in proper sequence. The possibility of future extensions must not be lost sight of.

Before the architect's drawings are proceeded with, the engineer should furnish the fullest particulars regarding his own work, and, for preference, supply blue prints showing by plan and section the several positions of the machinery and plant, and call attention to any special requirements for foundations.

By recognising these general observations it is believed that a better understanding will be established between the architect and engineer, whereby much unnecessary labour will be avoided by each of them, and that their resulting work will be carried out to their own satisfaction, and to that of their clients.

J. HERBERT PEARSON.

OBSERVATIONS IN GENERAL.

The meeting of 7th February emphasised once again the enterprise of the Juniors. The first of the Engineering Societies to take up aerial navigation as a subject for serious discussion, they have set an example which the other institutions may well follow, and the ball has been set rolling in no half-hearted fashion.

Mr. H. Chatley, B.Sc., who by the way has recently written an excellent treatise on the problem of flight, presented an admirable little paper as a basis of discussion. Without dipping too deeply into the theoretical considerations involved, Mr. Chatley neatly summarised the essential features of a successful aeroplane, and indicated the difficulties to be overcome. The paper is, however, presented elsewhere in *The Journal*, and may be commended for perusal to all who are interested in this subject.

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The most striking feature of the meeting was the rousing reception given to our distinguished French visitors, the Comte de la Vaulx, MM. Julliot and Capazza, and Captain Ferber, who were greeted with the enthusiasm for which the Juniors are renowned. This reception was fully justified by the instructive and charmingly phrased contributions of our visitors to the evening's proceedings. Our esteemed President, M. Canet, got a great reception too, *mais çela va sans dire.*

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The pretty little experiments shown by Major Baden Powell, quite simple, but full of practical interest, were much appreciated, while the Hon. C. S. Rolls gave a fascinating account of his experiences during a voyage in the airship "Ville de Paris," and Prof. H. S. Hele-Shaw, F.R.S., added materially to the information of the meeting by his entertaining remarks on stream-lines. With such a distinguished array of visitor speakers there was little time left for the genuine Junior to let himself go. Mr. R. H. Parsons, however, "took the word," as they say across the Channel, and made some very trite remarks. His description of Sir Isaac Newton as "a very good man in his day" was distinctly great.

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Quite the most modest, and unfortunately, the most disappointing of the speakers was Mr. A. V. Roe of *Daily Mail* prize fame. Mr. Roe merely said: "I have done my best to get results." Mr. Roe has done so much good work in experimenting with model aeroplanes, that the meeting really expected more from him. There are some folk in the world of aeronautics who talk a lot, but have done nothing. Mr. Roe's record is just the reverse, so come again Mr. Roe, and talk to us a little more.

"Eh bien!" Messieurs les Juniors, nous allons faire une petite voyage en France dans le mois de Juin prochain. Venez vous avec nous? Nous allons visiter Paris, Creusot, et Le Havre, ou nous verrons quelques-unes des plus grandes usines de la France. Nôtre Président nous a dit, dans sa manière si charmante et si aimable, que nous aurons un accueil le plus sincère que possible, et avec cette assurance nous sommes sur d'un très grand succès pour nôtre visite. C'est bien connu que les ingénieurs constructeurs de la France sont parmi les plus forts du monde et nous verrons beaucoup des choses d'admirer et de nous en profiter. Surtout it nous ferons grand plaisir d'avoir l'occasion de serrer la main de nos collègues de la France, et de visiter nôtre Président et nos nouveaux membres honoraires chez eux. Venez donc, Messieurs les Juniors, nous assister dans un occasion si heureux!

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Si vous ne parlez pas le Français çela ne fait rien, nous aurons des interprètes, mais vous avez encore le temps d'apprendre assez de la langue pour vous faire comprendre. Ca fera un joli compliment à nos voisins si tous les Juniors pourraient parler le Français. Essayez, mes enfants, c'est nest pas si difficile que vous le pensez.

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Bon!

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Oui, ça commence! Voyez en bas.

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ANSWERS TO CORRESPONDENTS.—A.B.C.: No, *homme de chaise* is not the best French expression for chairman.—D.E.: The phrase "*Apportez-moi un bock*" must only be used by non-teetotallers.—F.G.H.: If you call a cab-driver *cochon* you will hear some unpleasant remarks. It won't matter much, for you won't understand them. *Cocher* is the proper word to use.—J.K.: Practice saying "*Ton thé a-t-il oté ta toux*" very quickly. It will improve your facility of speech and puzzle your hearers.—L.M.: No, you are mistaken. Neither French mustard internally, nor French polish externally, will help to improve your accent.—N.O.P.: The *entente cordiale* is not a drink and has no connection with lime juice cordial.

(Owing to pressure on our space and the peculiarity of the requests for information, many replies are unfortunately held over.)

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The contribution of Sir Hiram Maxim (Hon. Member of the Institution) on "Balloons and Flying Machines" in the recent number of "The Times Engineering Supplement" appears most opportunely for us, and should be closely read. It reminds us, too, of the visit we paid to Sir Hiram at his home at Baldwyn's Park, Bexley, so long ago as June, 1895, reported in Transactions, Vol. V., page 270, when he showed us his flying machine, and ran it along the rails outside his workshop, and also demonstrated with his automatic machine gun, the operations of which were referred to in such a graphic manner by Lord Justice Fletcher Moulton and Col. Crompton at our recent Dinner.

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The report of that visit contains a description and illustration of Sir Hiram's aeroplane.

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We cannot refrain from quoting the following from Sir Hiram's article, as it has such a bearing on what Mr. Parsons said when referring to Sir Isaac Newton (1642—1727) at our meeting on the 7th February. Here are Sir Hiram's words :—

"When the writer was conducting his experiments at Baldwyn's Park, the late Lord Kelvin and Lord Rayleigh witnessed them on several occasions, and Lord Kelvin wrote that the experiments had proved most conclusively that Newton's law, as applied to such matters, was altogether wrong. Lord Rayleigh was of a like opinion, and later on he delivered a lecture to prove that the old conception of our mathematicians was very wide of the truth, and that the lifting effect of aeroplanes was vastly greater than anyone had ever supposed. The older mathematicians seem to have reasoned it out in the following manner :—

"The force of wind against any object is in proportion to the square of the velocity ; therefore if an aeroplane 20 in. wide, with the front edge tilted 2 in. above the horizontal, will push the air downwards twice as fast as it would if it raised only one inch, then the lifting effect would be four times as great. They therefore established this law, that the lifting effect of aeroplanes was in proportion to the square of the sine of the angle.

"According to this way of thinking, one aeroplane, 20 in. wide, with the front lifted 2 in. above the horizontal, would lift twice as much as two aeroplanes of the same dimensions, with the front edge lifted only 1 in. from the horizontal, but Lord Rayleigh has made experiments, demonstrating beyond all doubt, that the two aeroplanes, in which the sine of the angle is one, will lift considerably more than one aeroplane in which the sine of the angle is two. Therefore the old formula is extremely misleading ; moreover, some recent experiments made by the writer show that when well-made aeroplanes, placed at an angle of 1 in 20, are driven through the air at the rate of 80 miles an hour, the lifting effect is very much greater than anyone has ever supposed.

"There is no doubt that if an aeroplane were placed at a very low angle of 1 in 40, and driven through the air at the rate of 100 miles an hour, the lifting effect would be considerably more than 100 times as much as would be shown by the use of the old formula that I have referred to.

* * * * * *

Those of our members who attended our recent and most successful Annual Dinner will remember how delighted Col. Crompton expressed himself at having found Lord Justice Fletcher Moulton tripping at a quotation, and gave his Lordship some good humoured chaff on the point which was most admirably received by everyone and by no one less than by Lord Justice Moulton. But our curiosity compelled us to look up the quotation, and our members will be interested to learn that Lord Justice Fletcher Moulton was right and that Col. Crompton was wrong.

* * * * * *

It was announced at the last meeting that the Council had granted the petition for the formation of a local section of the Institution at Birmingham, which thus receives the distinction of being the first of our local sections. The whole membership will unite in wishing it a vigorous growth and every usefulness.

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Mr. R. B. A. Ellis' efforts are thus brought to fruition, and he is to be heartily congratulated on the realisation of what we know has been an ardent desire of his ever since he took up residence at Birmingham.

CONDUIT ELECTRIC TRAMWAYS.

The Seventh to Tenth Visits of the Twenty-seventh Session took place on Saturday afternoon, 11th January, 1908, by permission of the Chief Engineer, Mr. Maurice Fitz Maurice, C.M.G., to the London County Council Tramways Reconstruction Works in Stockwell Road, the Clapham Road Car Shed and Motor School, and the Clapham Sub-Station.

The party, numbering 78, were met at 3 p.m. by Mr. Alexander Millar (Resident Engineer) and Mr. Fitz Roy Roose, author of the paper read before the Institution on the 8th January (page 217 *ante*). The method of forming the concrete conduit by means of improved sheet-iron centering, the process of inserting the copper connecting pieces between the lengths of conductor bars, the insertion of the insulators, and manner of carrying out other special work were demonstrated.

Conducted by Mr. J. Bowden, rolling stock superintendent, the members then proceeded from "The Swan," Stockwell, to "The Plough," Clapham, by one of the latest types of cars, Class E1, which had been sent for their use by direction of the Chief Officer, Mr. A. L. C. Fell, who was unexpectedly prevented from being present as intended. Switched off the main track, the car was run into the shed on to the electric traverser, and moved thereon to illustrate the method of bringing the cars into their places in the depôt. In the motor school, full particulars were given by the Motor Instructor, Mr. R. Baron, of the system of teaching, and after viewing the sub-station, the car sheds were inspected, under the guidance of Mr. Bowden.

Before dispersing, Mr. F. R. Durham, the Chairman of the Institution, conveyed the members' acknowledgments of the facilities which had been kindly afforded in connection with the arrangements of the afternoon.

Tramway Reconstruction Work.—For description of the tramway reconstruction work, reference should be made to Mr. Roose's paper, as mentioned above.

For the following the Institution is indebted to Mr. A. L. C. Fell:—

Clapham Car Shed.—This is used for housing cars operating on the Tooting, Balham, Clapham to the Bridges section of the Council's Tramways, and is situated at the point where Clapham Road is joined by Clapham Park Road. It will accommodate 176 cars of the bogie or eight-wheeled type.

The Depôt has two single track entrances, one *via* Clapham Park Road and one direct from Clapham Road. Both these tracks are connected to the up and down lines. A pit runs transversely across the Depôt in which are two traversers for transferring the cars from the approach tracks to the other tracks, there being 26 tracks on each side of this pit and at right angles to it ; ten of them are solid, and the remainder are provided with inspection pits. Current is conveyed to the cars by means of the same plough that is used in the street, and is collected from conductor rails fitted at the side of each pit. The outer rail is mounted on a teak shutter, which prevents the men from coming into contact with it. In the case of the solid tracks the conduit construction is similar to that in the street. The traversers are carried on four steel tyred wheels and are fitted with one standard traction motor and two controllers ; the current being taken from tee bars fitted in the sides of the pit. At each entrance to the Depôt there are offices for receiving the money taken during the day. In addition to these offices there are the stores for spare parts, washers' materials, &c., and for car tool boxes, a foreman's office, and mess rooms for the Depôt employees, drivers and conductors. Three tracks at the north-west corner of the Depôt are partitioned off from the remainder and are provided with heating apparatus to form a temporary paint shop pending the completion of the Central Repair Depôt in Woolwich Road.

Clapham Motor School.—All drivers engaged by the Council, after being passed by the Medical Examiner, have to undergo a course of instruction at this motor school. The school can be entered without going through the Depôt, and lies at the south-eastern corner of the car shed, adjacent to the sub-station. The school is equipped with a stationary car which is complete in all details. It is mounted on rollers, and can be worked in the same way as a car running on the street, the current being taken from a conduit under the car by a plough in the ordinary way. The cars carry a complete set of tools and lifting jack, which the men are taught to use. They are also instructed how to take out and replace a plough in a live hatchway when the power is on the line, and in the use of the telephones.

Around the school are stands upon which are mounted the different types of controllers in service on the system. With each

controller is a brake spindle connected by chain to a spring, a gong and sand pedals. These are arranged in similar relationship one to another as when on the platforms of the cars, the object being to allow men to practice the working of the controllers and brake handles before going on the road with the training car. Instructions are given as to the proper working of the controller and the different notches are fully explained to them. Whilst practicing they attend lectures which are given, fully explaining the working of all parts of the equipment, including the brakes, both electric and magnetic.

The men are then placed for a time on each route with a reliable motorman to learn the stopping-places and different speeds allowed; after this they are taken in hand by an Instructor, who tries them through the busiest part of the traffic, and if found efficient he reports to the Principal of the school, who arranges for the men to be examined. Each man is required to demonstrate that he can efficiently and properly handle the controller, brake and sand gear, and the tools carried on the car. He is also examined as to his knowledge of the functions of the various parts of the electrical equipment. On satisfactorily passing this examination he is granted a certificate showing him to be capable of driving a car in traffic.

After six months' service he is entitled to extra pay; this is only allowed when the men have passed another examination in the school, and each time a man's increase is due he must attend the school to show that he is keeping up with the instructions given. The school is open each day for inspectors, regulators and motormen, who can avail themselves of any information they require as to the working of the car.

Clapham Sub-Station.—The sub-station at Clapham receives electrical energy from the Greenwich Generating Station at 6,600 volts pressure of the three-phase alternating current variety. The sub-station contains at present three induction motor generators, and a fourth is now being erected. The function of these machines is to transform the high tension supply received from Greenwich into a low tension direct current supply for immediate use on the tramway tracks. The pressure of the transformed supply is 550 volts, and at this pressure the current is sent out by underground cables to the tramways in the neighbourhood of the sub-station, some five miles of double track being fed.

The switchgear of the sub-station is arranged to control and

measure the high tension supply from Greenwich, and the low tension supply to the tramways. Instruments are provided by which the attendants can ascertain the character of the fault, if any, on the tramway track, and the whole apparatus has been designed with a view not only to give full information of the nature of the fault, but so that it can be located and put right at the earliest possible moment. A 10-ton crane spans the sub-station, and is used during the erection, and afterwards for the maintenance of, the plant. The usual mess-rooms, lavatories, &c., are provided for the staff, and the men work on 8-hour shifts, as the sub-station is always running.

AERIAL NAVIGATION.

The Fifth Meeting of the Twenty-seventh Session was held at the Royal United Service Institution, Whitehall, on Friday, 7th February, 1908, the attendance being 210.

The chair was taken at 8 p.m. by the President, M. Gustave Canet, and the minutes of the previous meeting of 8th January last were read, confirmed, and signed.

THE PRESIDENT, in his introductory remarks, referred to the special character of the meeting. The Council, realising the desirability of the members being kept abreast of all that was latest in engineering science, had decided to ask some of the well-known French and British authorities to attend and assist in a discussion on the subject of aerial navigation, to be opened by a paper from the pen of Mr. Chatley. They were fortunate in having with them that evening Count de la Vaulx, Vice-President of the Aero Club de France; M. Julliot, the designer of the balloon "La Patrie"; Capt. Ferber, deputed to the Laboratory for the investigation of French military aeronautics, and M. Louis Capazza, engaged on the construction of a balloon designed on new lines, who had done them the honour of coming over from Paris specially to attend; there were also present Major Baden-Powell, the Hon. C. S. Rolls, Dr. Hele-Shaw, Mr. A. V. Roe and others, while expressions of regret at absence had been received from Sir Hiram Maxim, Col. Capper, Col. Templar, Mr. S. F. Cody, Mr. Henry Farman, Professor W. H. Dines, Mr. Louis Brennan, Dr. T. E. Stanton and Mr. F. W. Lanchester. He then called on Mr. Chatley to read his paper and to show the lantern slides he had brought to illustrate it.

The paper having been read, communications by M. Julliot, Capt. Ferber, M. Capazza, and Count de la Vaulx were presented (the two former being illustrated by lantern slides); followed by speeches from Major Baden-Powell, the Hon. C. S. Rolls, Dr. Hele-Shaw and Mr. R. H. Parsons.

THE PRESIDENT then said that all would agree they had had a most valuable and interesting discussion. He wished to propose a hearty vote of thanks to the author of the paper and to all who had assisted in the discussion. The members of the Junior Institution of Engineers he was sure, would ever regard the evening with much satisfaction and pleasure. To the French gentlemen who had gone to so much trouble in attending, the Council desired him to tender their special thanks.

The vote of thanks was carried by acclamation, and the author having replied, the proceedings closed with the announcement of the ensuing meeting on the 12th February, at the Architectural Association, 12 Tufton Street, Westminster, when a paper on "Suggestions as to how the Architect and Engineer can Combine," would be read by Mr. P. J. Waldram, Past-Chairman, and the ensuing visit on Saturday, 22nd February, to King's College for an inspection of experimental apparatus, &c.

MEETING OF MEMBERS AT BIRMINGHAM.

The Fourth Meeting of Birmingham members and their friends was held on Monday, 10th February, 1908, at the Headquarters of the Electrical Engineer Volunteers, Birmingham Detachment (by permission). There was an attendance of 20, of whom 14 were visitors. Mr. A. J. Rowledge, A.M.I.Mech.E., took the chair at 8 p.m.

The minutes of the previous meeting having been read, confirmed, and signed, the Chairman first called upon Mr. R. B. A. Ellis to read the reply of Mr. Fitz Roy Roose (published in the February issue of *The Journal*) to the discussion upon his paper on "The Conduit System of Electric Tramway Construction," read at the previous meeting.

Mr. Herbert Chatley's paper on "Aerial Navigation" was then read by Mr. Ellis.

A hearty vote of thanks was proposed by Mr. M. R. Parker (member) to the author for the interesting paper which he had prepared. To one not familiar with the problems

involved, the power required for propulsion seemed great. Mr. E. G. S. Vaughan (member) seconded the vote of thanks, and remarked that the Institution was to be congratulated on having brought the subject forward. The paper and discussion he felt sure would form a very valuable asset in the Transactions. Mr. T. H. Relton (member) suggested that a turbine could be successfully used for rotating the helices, one on the Pelton-wheel principle, driven by steam, as experimented with by Mr. S. Z. Ferranti, or perhaps a series of small electric motors on one shaft could be used.

Mr. North, B.Sc. (visitor), referred to the circumstance that although the first successful flight of a closed kilometre had been accomplished by an Englishman, it had not been due to English money. The author stated that the "Antoinette" motor was made by the Adams Manufacturing Company, whereas he (Mr. North) believed they were only the English agents for the sale of the motor. It was a very interesting type of motor from the fact that aluminium combustion heads were used. The engine designed by M. Esnault Pelterie was also one exhibiting great ingenuity. He was surprised to learn that ventilating fans did not give a higher efficiency than 50 per cent. Gyrostats would no doubt play an important part in the future of the aeroplane.

Mr. Borthwick (visitor) believed 100 H.P. was required for every ton to be raised. Messrs. Boggust, Tebbit and Tabbaner also joined in the discussion, and Mr. Ellis in his remarks thought it was not at all improbable that inventions yet to be developed would revolutionise all previous ideas on the subject.

The Chairman remarked on the great credit due to the designers of the extremely light motors employed. The weights of the French motors quoted were simply astounding to anyone with experience in petrol motor design. He was relieved to hear that there were yet many difficulties to be overcome before airships could be regarded as of much value for military purposes, and quoted M. Santos Dumont as to the need of harbours for these craft, both for safe landing and protection from storm. He then put the vote of thanks to the meeting, which was carried with acclamation.

A vote of thanks, proposed by Mr. Relton, seconded by Mr. Borthwick, having been passed to Mr. Rowledge for taking the chair, the proceedings terminated with the announcement of the ensuing meeting on 20th February.

"AERIAL NAVIGATION,"

By HERBERT CHATLEY, B.Sc. (Engineering), Member; of Portsmouth.

Read 7th February, 1908.

It is extremely appropriate that the subject of Aerial Navigation should receive the special consideration of the junior members of the profession, since it is emphatically one which concerns them more than it does their older colleagues. In the first place it has only assumed quite recently a form free from crankishness; secondly, it calls for actual risk of life in certain experiments; and lastly, it promises to be *the* subject of the near future. The writer does not wish it to be supposed, however, from this statement, that he holds that within a very few years aerial propulsion will become of more importance than the present means of locomotion on land and sea, but he does suggest that definite results, already achieved, indicate it to be a subject which no young engineer can afford to neglect.

The history of the attempts that have been made to imitate natural flight is fairly well known, and does not call for detailed treatment in the present paper. It is a long record of almost continuous failure, such failure being due to lack of knowledge concerning the mechanics of flight, and to inadequacy of motive power. Within the last fifty years, however, more scientific methods have been employed, and it was acknowledged by most engineers so early as 1900 that Professor Langley's work at the Allegheny Observatory had conclusively proved the possibility of mechanical flight. As regards the balloon type, the same period has been fruitful of great developments, so that now every one of the great nations possesses in its army the nucleus of a squadron of dirigible balloons.

If the various types which have persisted through the struggle for existence be studied, it will be found that they may be briefly classified as follows:—

1. *Lifting Force obtained from Flotation.* Including the balloon in all its varieties.

2. *Lifting Force obtained from Momentum.*

(a) *The Aëroplane* or kite, which is pulled or pushed against the air, the relative change of momentum producing an upward and backward thrust.

(b) *The Helicopter* or vertical screw machine, which is sustained by screw tractors (*not* propellers in the true sense of the word) which project air downwards, the gain of momentum per second producing an upward thrust to balance the weight.

(c) *The Aviplane* or bird machine, which attempts to imitate the flapping action of the wings of bats, birds and insects. This is of the simple two-winged bird type, and also of a rotary type.

THE AËROPLANE.

The author proposes to deal most particularly with the first type of the second class, *i.e.* the Aëroplane, because a correct understanding of the principles of this device is essential before the others can be rightly considered. Furthermore, the results obtained from it are at present better than those given by the second and third types.

The Aëroplane may be defined as a surface, plane or curved, which, being inclined and drawn or pushed by a screw against the air, is subject to an upward thrust due to the action of displaced air on the underside and inrushing air on the upper side.*

It should be noticed, however, before proceeding further, that the efficiency of the arrangement depends quite as much on the driving screw as on the plane.

A careful study of moving aëroplanes leads to the observation of the following phenomena :—

(1) A displacement of the air immediately in front so that the stream lines are distorted and can only return to their normal directions some distance behind the plane.

(2) In front of the plane a cushion of comparatively still air forms, which breaks up the impinging stream some little way in front of the plane.

(3) Behind the plane the space swept out is filled (back to the junction of the stream lines) with eddies of air due to the whirling of the stream of air round the edges of the plane. The total

*It is not proposed, in view of the severe warning given to "x-chasers" in the first number of the Institution's Monthly Journal, to enter into much mathematical detail.

pressure in this space is less than normal, so that the pressure on the underside is increased by a negative pressure or "suction" on the upper side.

(4) There is skin friction where the stream passes over the surface of the plane.

(5) A wave is propagated through the air in front of the plane.

Quantitative experiments lead to the following conclusions:—

(1) The normal pressure on the plane varies as the area, and as the square of the velocity. There is also a slight variation due to the changes in the temperature and pressure of the atmosphere. Generally, on a plane moving normal to the air stream (which, by the way, is rarely horizontal) the pressure in pounds = 0·00166 × (velocity feet per second)^2.

(2) The normal pressure on an inclined plane varies with some function of the angle. This variation is far more considerable at small angles than at large ones. In fact, from 60° to 90° there is very little change of pressure. For small angles the variation may be taken roughly as sin θ, *i.e.*, normal pressure on inclined plane = normal pressure on normal plane × sin θ. This is only, however, very approximate. For square planes, the Duchemin rule, which gives $\frac{2 \sin \theta}{1 + \sin^2\theta}$ is more accurate, or Unwin and Hutton's more complex form $\sin \theta^{(1{\cdot}84 \cos \theta - 1)}$.

Yet again, there is Lord Rayleigh and Gerlach's rule $\frac{(4+\pi) \sin \theta}{4+\pi \sin \theta}$, which applies, however, only to narrow planes. Professor Dines gets still greater ratios between 30° and 50°.

(See appended Table and Diagram).

Great reliance, however, must not be placed on this for other shapes of plane, since Langley has shown that on a long plane moving with its width towards the direction of motion, the pressure is more, and on one placed with the length in the direction of motion the pressure is less. At about 30° inclination all have the same pressure.

(3) The pressure on an inclined plane is not uniformly distributed, but decreases in intensity from back to front, so that the centre of pressure is in front of the centre of gravity. The maximum displacement is about $\frac{1}{3}$ the length of the plane (in the direction of motion). This displacement varies also inversely as the sine of the angle; is greater for small angles on planes long

in the direction of motion and the reverse for planes short in that direction.

This fact greatly complicates the question of balance.

(4) On a curved plane there is a greater thrust upward than on flat planes, and if a plane with a small curvature be propelled with the chord of the curve horizontal there is a very great thrust (*i.e.* much greater than on the same plane when flat) up into the concavity, probably due to a large suction pressure. [Note.—It appears that the replacing air creeps in over the back edge of the plane, so accounting for the smaller pressure there and the great suction pressure in the forward parts of the plane.]

Having regard to the above, it is now possible to state:—

(1) The thrust or pull from the screw must exceed the greatest resistance from the plane (*i.e.*, the horizontal component of the normal pressure plus the resistance of framing, &c.).

(2) The weight supported must be less than the least available lift from the plane (*i.e.*, the vertical component of the normal pressure).

(3) Balance must be maintained by keeping all the forces so that they have no turning moment about the centre of gravity.

Langley's Paradox.—It will be evident from the foregoing that the thrust (and consequently the lift and resistance) depends on the area, speed, angle, and position of the plane, so that if speed be increased, the angle may be reduced, and this leads to Langley's paradox, viz., that the greater the speed the less the power. It must, however, be borne in mind that this does not include the alterations in kinetic energy or the resistance of the car, &c.

Arrangement of Planes.—As regards arrangement of planes, it has been found best to pair them laterally (like the wings of a bird when soaring) or superpose them in tiers (like a Venetian window blind), or arrange them behind one another. The latter arrangement is only to be adopted after great care, since if the planes are near to one another the front one obstructs the flow of air to the back. A distance apart equal to the width of the plane (in the direction of motion) is necessary, or more if the planes are not very flatly inclined.

As regards the angle of the plane, this should be reducible from 25° to 0°. The first angle gives approximately the maximum lift and minimum resistance, and so is suitable for

commencing after a run on the ground. The angle may then be decreased as the speed increases, until *when* a speed of 60 miles per hour has been attained the plane can be horizontal. This is another of Langley's paradoxical results.

Some inventors have used the boxkite (invented by Mr. Hargrave, of New South Wales) form, and it seems to be more stable, limiting the escape of the air. On the other hand, it exposes a large surface to lateral winds.

The Screw.—There is yet another and more serious problem to be considered, namely, the value of the screw (or as the writer prefers to call it, on account of its diversity of uses, the helix).

In ordinary machines a horizontal screw rotating either moves itself laterally or the piece in which it rotates. A propeller acts partly in both these ways, and it will be convenient to consider the various actions of the screw under different circumstances, as the size, pitch, &c., depend very much on the mode of application of the screw.

Briefly, a screw or helix is used in the following ways :—

(1) For Ventilating. Here it corresponds to the screw moving the piece in which it rotates, since a cylinder (?) of air is projected from it. A thrust is produced in the bearings which again produces friction, work being absorbed from this cause.

(2) For Propelling. Theoretically this corresponds to the screw which moves itself, but unless it can move with this full speed, the piece itself is moved to some extent, *i.e.*, the air is projected. This corresponds to what marine engineers call slip.

(3) For Pulling (Tractor Screw). The action here is the same as propelling, but fresher air is received, although probably the air leaving the screw is not so useful for lifting the plane.

(4) For Lifting. The action here is a combination of (1) and (3). The projected air must have a backward change of momentum equal to weight, the residual thrust giving upward acceleration.

(5) For Supporting. This corresponds almost exactly to No. 1.

We see then that the helix varies in action from the state of propelling itself wholly to propelling the air wholly. In the first case the velocity is supposed to be found by multiplying together the pitch in feet by the revolutions per second. In this case, in order that there shall be as little resistance as possible, the blades

are made as small as practicable consistent with the transmission of thrust, so that for propelling purposes it has been found best to use large diameter fan bladed propellers.

In the second case, the momentum effect on the air depends on the pitch, revolutions, and areas of the blades, since it is desired to move as large a mass of air as possible. The blades should then have an area which is equal practically to the whole of the projected pitch circle. Compare the Blackman ventilating fan. Such screws would be most suitable for sustaining purposes, or even lifting, if the vertical speed is only to be small.

It is greatly to be regretted that precise knowledge of the phenomena of propellers is so meagre and unsatisfactory. Experiments in this subject are urgently needed, but it may be pointed out that Langley has shown that a fan-bladed propeller of small area is capable of producing a thrust which indicates a mechanical efficiency of about 50 per cent.

Considerable information on this subject can also be obtained from a paper by Mr. Walker in the Philosophical Transactions of 1900. From this it may be deduced* that in a full area propeller the thrust varies as the revolutions, the cube root of the horse power, and about the square of the helix diameter.

The use of propellers with superposed blades is also permissible, the thrust being sensibly increased. As regards the effect of propellers in keeping the vessel straight, unless they are paired (as in marine practice) the thrust will always pass axially through the vessel (it should go through the centre of gravity) and so have no steering effect.

Weight of Machinery.—The question of weight of propelling machinery has now received a satisfactory solution in the petrol motor which the Adams Manufacturing Co. has succeeded in reducing to a kilogram (2·2 lbs.) per H.P. Taking the efficiency of the propeller as 50 per cent. and adding a small percentage for weight of transmission gearing and propeller, a weight of 5 or 6 lbs per H.P. for the machinery is quite possible, and a surplus of lifting thrust per H.P. above this, sufficient to lift the planes, is easily attainable with even flat planes. That this is so has been clearly shown by M. Santos Dumont's successful flight in November, 1906, where a lift of ½ lb. per square foot was

*See "The Problem of Flight," by H. Chatley, p. 10.

obtained in a machine weighing 463 lbs. (with aeronaut), a 50 H.P. motor being used (weight rather over 1 cwt.).

Although, as already shown, the weight per square foot depends on the angle and speed, it would appear from numerous experiments that the maximum desirable weight per square foot is about 2 lbs. The Australian crane, which is a good flier, has the smallest wing to weight ratio—0·41 square foot per lb., *i.e.*, about 2·4 lbs. per square foot. Maxim's steam machine, which was partially successful, had 8,000 lbs. supported by 4,000 square feet, *i.e.*, 2 lbs. per square foot. Langley's aerodrome, which was entirely successful, had about the same ratio.

Balance.—Another and vital problem is the question of balance. From mechanical principles the essential condition of this is that the torques about the centre of gravity should always neutralise one another. The maintenance of this condition is greatly complicated by the fact that the centre of pressure on the planes shifts with the angle, and even when proceeding quite horizontally the air currents are frequently to some extent vertical, so that a relative change of angle can occur without any deviation of the machine. Again, the movement of the aeronauts will cause deviating torques.

It is therefore necessary to provide some means of obtaining a torque to neutralise accidental turning effects. The following devices can be employed:—

(1) Small planes, remote from the centre of gravity, which can be rotated by levers so that the air stream pressing on them will turn the machine against the accidental torques. These are, of course, entirely analogous to rudders (which also will have to be used for steering horizontally). The author does not think that this arrangement will be sufficiently responsive or powerful under all circumstances, although it has been adopted by many inventors.

(2) Differential screws which, paired and working against one another, can produce righting torques.

(3) Travelling counterpoise or jockey weight, as in the Wicksteed Testing Machine or Steelyard.

(4) The Gyroscope, as in the Brennan Railway.

This last seems to be the most hopeful, since it is quite automatic and can be extremely powerful.

To operate it, a small dynamo, driven from the main engines,

or perhaps better, from accumulators, would supply current to motors, the rotors of which are attached to the gyroscopes. Two pairs of gyroscope fly wheels would be required to give lateral and longitudinal control.

Construction.—All the more important points have now been considered, but many others must be attacked by the designer of an aeroplane. For example, the carriage which supports the aeroplane on the ground while it attains its soaring velocity, and the springs required to absorb the energy of contact in striking the ground.

As to the materials and method of construction, it has been found best to construct the framework in steel tube. There is no great advantage in using aluminium, as, strength for strength, it is not much lighter. The surfaces may be of silk or aluminium. Corrugated aluminium (about $\frac{1}{4}$ inch pitch, $\frac{1}{8}$ inch deep) has also been used with some success. The longer rods should be trussed on the Bollman principle, and any surfaces which tend to rise or fall should be fixed with guy-wires to central struts in umbrella fashion.

The motor at present in favour is that made by the Adams Manufacturing Co. (the "Antoinette"), with four, six or eight cylinders obliquely paired. The central frame shaft supports the motor from above, and the propeller shafts may be paired on either side of this, at the same level, so that the resultant thrust passes through the centre of the frame. About this frame the car should be constructed. The author considers that the car should be enclosed and present a wave profile upwards and forwards, so that there cannot be great resistance to its motion. It should be noticed that the resistance of an open framework is very considerable, whereas a form corresponding to stream lines (sinuous or torpedo shape) offers very little. The covering may be cane or aluminium (a polished surface is preferable).

The propellers can be similarly constructed in steel and silk. They should run at upwards of 2,000 revolutions per minute and have a pitch about equal to the diameter.

BALLOONS.

As regards the balloon, the laws of resistance to motion and stream line profile apply, so that recent inventors have adopted the torpedo form. This is well illustrated in the Lebaudy balloon

"La Patrie," which, before its unfortunate flight to this country, could often be seen hovering over the streets of Paris. The objections to the balloon as a permanent flying device are due principally to its lack of inertia and the insufficient strength of its envelope.

Lack of inertia will always make it impossible to move against a very powerful wind, since the resistance (due principally to skin friction) on a large balloon is very considerable. The second feature appears when the effort is made to force the balloon against a powerful wind, *i.e.* travel with great velocity relatively to the air, since great stresses are set up in the envelope, and no known material is at the same time light enough and strong enough to withstand them.

HELICOPTER.

The helicopter or vertical screw machine depends for both its support and locomotion on helices. The disadvantages of this type will be apparent from the following:—

(1) The lifting efficiency of a screw is considerably less than that of an aeroplane. (This was shown by Lord Rayleigh in 1900.)

(2) There is no diminution in resistance at high speeds, since the projected area cannot be reduced. It has been suggested, however, that by means of aeroplanes used in conjunction with lifting screws, this difficulty would be overcome.

(3) There is no initial stability.

(4) Failure in screws means catastrophe.

The advantages are, however, great, viz.:—

(1) The machine can lift directly from rest.

(2) The ascensional force can be varied at will by altering the speed of the screws.

(3) With suitable casings over the car and helices, a very small lateral resistance can be obtained.

(4) Landing can be accomplished without difficulty or shock.

(5) Righting torques can be produced by differential motions of the helices.

THE AVIPLANE.

The Aviplane or flapping type acts very similarly to the aeroplane on the downward stroke, but encounters certain difficulties

on the return movement. In flying animals there is a rotation of the wing, so that the return movement is obliquely upwards and backwards, the inrush of air following the down stroke being thus utilised to produce the horizontal thrust. The essential principle is that on the downward stroke the pressure shall be principally vertical (it also has a slight backward component), and on the up stroke the pressure must be mainly horizontal (there is also a slight downward component). This involves rotation as well as reciprocation, and this has been the chief difficulty experienced by the innumerable inventors who have tried this type. The writer has suggested that it is possible to produce this motion by arranging a ball and socket joint in the chief rib of the wing plane, the inner end of the rib being guided in a cam groove so as to produce rotation, while there is at the same time a reciprocating motion given to the wing by a piston.

Another scheme acting in a very similar manner is a vertical wheel, on the spokes of which are fans, which on the down stroke are horizontal and on the upstroke vertical. (Horizontal thrust produced by propellers.) A cam in the circumference of the wheel would operate the necessary trip gear to rotate the fan blades, but there would be much friction.

Although natural analogies seem to indicate this class as the best, on the other hand it must be remembered that in animals the means of locomotion is derived from within a very small space, so that the lever principle, instead of the wheel, is essential. In a machine, on the other hand, the propeller with rotary motion would seem to be more effective.

CONCLUSION.

As to the practical uses of aërial navigation, they may be threefold :—(1) Military ; (2) Scientific ; (3) Commercial.

(1) The military purposes are of course the most important, but even here there are considerable limitations. For reconnoitring purposes and despatch work small aëroplanes should prove to be very useful.

For bombardment and artillery even large machines would seem to be subject to several difficulties. In the first place, the reactions from firing even very light artillery would produce large disturbing forces on the vessels on account of their comparatively small inertia and lateral resistance.

As regards the dropping of explosives (which is, by the way, supposed to be prohibited) there would be considerable difficulty in aiming the bomb, as the balloon or aeroplane would have motion and the air through which the bomb fell would also have motion. This difficulty may not be insuperable, but it is by no means unimportant.

As regards danger, unless the machinery of an aeroplane was struck by a projectile the danger would be far less to this type than to a balloon, since the resistance would be only slightly diminished by a hole the size of the projectile (it could not be much bigger with this material), whereas a balloon would collapse, or if in compartments, be seriously impeded.

(2) The scientific use of aeroplanes and balloons in connection with meteorology is already well developed, and later, possibly surveying and geography may benefit.

(3) For commercial purposes there is not any great prospect of the application of aërial navigation yet, but the aeroplane should provide a means of rapid transit for small goods and other articles of no great weight.

In conclusion, it may be said that although there is no justification for making such extravagant claims on behalf of aerial navigation as novelists and some inventors who could not sell their patents have done, yet the subject has now reached such a definite phase that no intelligent man, and especially the engineer, should overlook its growing importance.

(See pages 281—282 for Table and Curves.)

AERIAL NAVIGATION.

TABLE OF RATIO BETWEEN PRESSURES ON INCLINED AND VERTICAL PLANES.

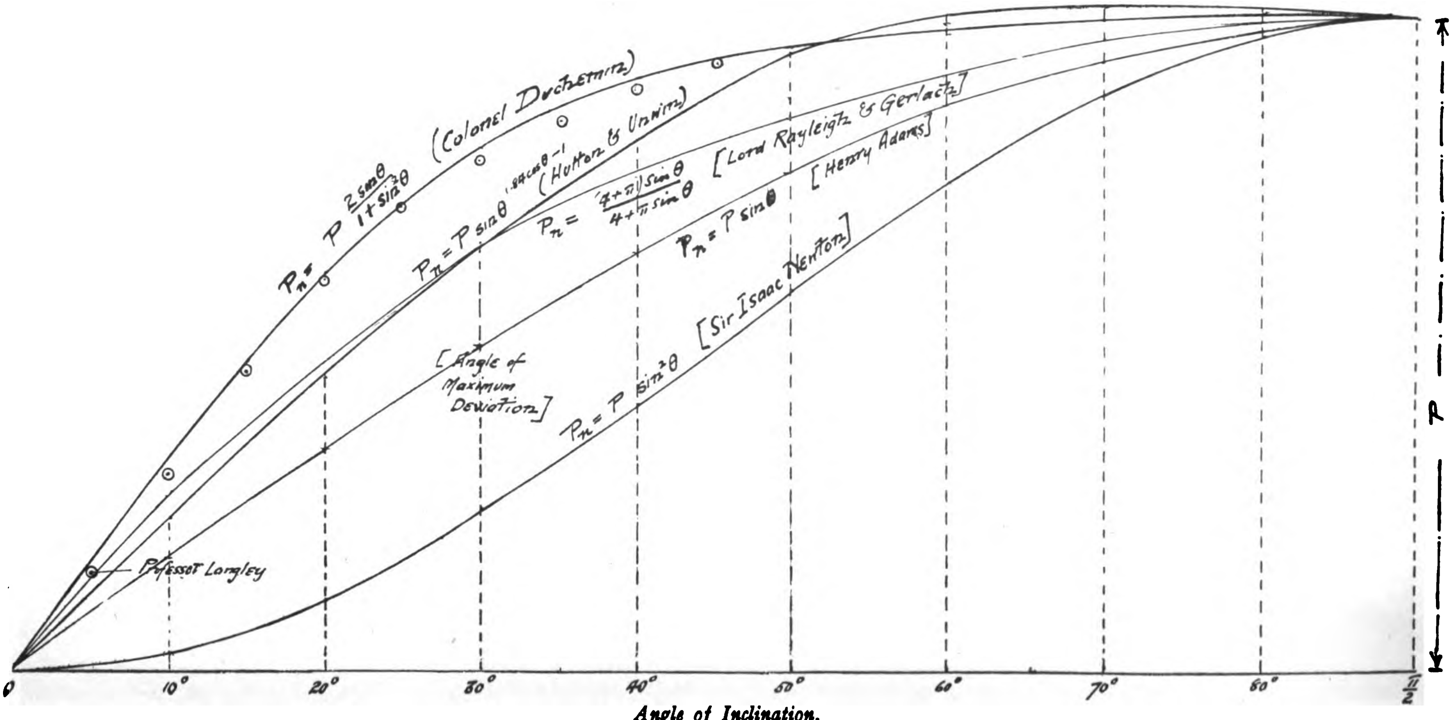
(See Diagram).

Angle of Inclination, θ	Colonel Duchemin's Formula, $P_n = P \frac{2 \sin \theta}{1 + \sin^2 \theta}$	Dr. Hutton and Professor Unwin's Formula, $P_n = P \sin \theta^{1 \cdot 84 \cos \theta - 1}$	Lord Rayleigh and Gerlach's Formula, $P_n = P \frac{(4+\pi) \sin \theta}{4 + \pi \sin \theta}$	Sir Isaac Newton's Momentum Principle leads to $P_n = P \sin^2 \theta$
10°	0·3365	0·2358	0·274	0·03015
20°	0·6158	0·4574	0·463	0·1169
30°	0·8000	0·6622	0·643	0·2500
40°	0·9103	0·8168	0·761	0·4131
50°	0·9651	0·9526	0·850	0·5868
60°	0·9897	1·012	0·912	0·7501
70°	0·9977	1·023	0·975	0·8831
80°	1·0000	1·013	0·995	0·9699
90°	1·0000	1·000	1·000	1·0000

AERIAL NAVIGATION.

Variation of Normal Reactions (Square Plane) with Inclination.

(See Table.)



DISCUSSION ON AERIAL NAVIGATION.*

"DIRIGIBLE BALLOONS IN WARFARE,"

By M. Julliot, Engineer.

Gentlemen—

I am very pleased to be with you this evening in response to an invitation which was kindly sent me by your President, M. Canet. I may say, in the first place, that I have been styled the pioneer in the manufacture of dirigible balloons, and as one should only speak on subjects he is acquainted with, it is on this subject that I shall discourse to-night. It was in 1896, during a period of convalescence which had rendered my capability at once keener and more weak, that I let my thoughts dwell on the possibility of realising the solution of the aerial navigation problem. My first scheme was only a work of imagination without much practical value; but circumstances enabled me to add to this the necessary corrections and placed in my hands the means to go forward. The chief of these have reference to the progress made in metallurgy, resulting in the manufacture of nickel steel; to the progress made in the motor car industry, which has given us more and more powerful explosion motors of light weight and safe working. They also have reference to the enlightened, continuous and powerful aid I have received from Messrs. Paul and Pierre Lebaudy.

By these means, we have been able to manufacture two dirigible balloons, the "Lebaudy" and "La Patrie." Both have since become the property of the French Government; they were designed for speed and staying qualities, both of which are necessary for a wide field of usefulness in warfare.

Description of Balloons "Lebaudy" and "La Patrie."—They consist mainly of the following parts, almost all of which can be seen in the model exhibited. There is, in the first place, and with a view to sustentation without mechanical assistance, the balloon proper, containing 3,500 cubic metres (123,608 cubic feet) of hydrogen; this is 62 metres (203 feet) in length, of modified egg shape, pointed in front in order to reduce the air resistance, and rounded in the rear. The largest cross-section, 10·90

*For the translations of the following four contributions we are indebted to Mr. G. Lemey and Mr. R. H. Parsons.—Ed.

metres (35 feet 9 inches) in diameter, is in front of the centre, this being favourable to stability.

The balloon envelope is made of panels of tissue with double indiarubber covering, of high resistance and good gas-tight quality, as is also work resulting from the method followed of sewing and glueing the panels together. The material is yellow, so that light should not have a deteriorating effect on the india-rubber; it is smooth, and no netting is used, as this would indent it and cause resistance to forward motion. The balloon can remain filled for several months, with only a small additional supply daily.

Permanency in shape is an indispensable factor in forward movement, and it is assured by a fan and a small adjoining balloon by means of which an inside pressure of about 25 milli-metres (one inch) of water is maintained.

The balloon is provided with four kinds of planes arranged below and in the rear; there are fixed horizontal planes, and fixed vertical planes which cross the horizontal ones. They serve to prevent pitching, rolling and oscillating motion. The planes in the centre resist the above kinds of motions when proceeding from any outside cause, while those in the rear counteract motions due to an inside cause.

The other planes provided are movable. These are: the vertical rudder for steering, and the horizontal rudders or planes which can be unrolled, for rising and descending within a certain range without expenditure of ballast or gas.

The fixed horizontal planes are arranged so as to form a strong central frame with lighter end portions attached to it. The balloon is attached to this frame in such a way as to undergo slight and pre-determined deformations should it become flabby by reason of reduced internal pressure. By this means, such deformations cannot lead to the tearing of the envelope nor to failure of the car suspension gear, as would result were the latter to join the car and envelope directly.

The motor is a 70 H.P. petrol motor of present day automobile type. It drives two rigid, metallic, lateral propellers, 2·50 metres (8 feet 2 inches) in diameter, free of any incumbrance both in front and in the rear. They revolve in opposite direction, in order to prevent any secondary effects. They work at a speed of

1,000 revolutions per minute to overcome the eddies, and variations in velocity of the air.

The car is short, and boat shaped; it is suspended to the main fixed portion of the frame by incollapsible suspension gear, formed of wire cables, the strains being by reason of the method adopted independent of the variations in shape of the envelope. The car is less firmly connected to the jointed end portions of the frame. It is made with a strong keel, which allows of sudden landing in a high wind, without any danger. The car and all the lower elements of the apparatus are of metal, and therefore fireproof.

The above component parts of the machine have not the disadvantages to which balloons were formerly subject, and which Mr. Chatley mentions at the commencement of his paper, probably with a view to open discussion with regard to them.

The inertia, or in other words, the mass and the arrangement of the fixed planes of our apparatus are such that their velocity is proportional to the motive power, and, everything remaining equal, it will suffice to place in our balloons motors of gradually increasing power for the same weight to increase the travelling speed without fear of encountering any insuperable limit.

In the same way, the strength afforded by the shape of the envelope, filled and so maintained by sufficient internal pressure, is such that speed can be much increased without fear of telescoping or deformation. Thus previous to the accident to the "Patrie," at Verdun, this balloon withstood the force of a wind travelling at a speed of 20 metres (66 feet) per second; when this wind took the balloon sideways, it carried away the hawsers, but when it took it end on, no deformation occurred, the point was not depressed, and the envelope did not become detached from its lower framing. This affords practical proof of what was well known from theory, that semi-rigid balloons can stand speeds of 20 meters (66 feet) per second without it being necessary to surround them with a complete casing strengthened with metallic stays. Neither is this friction an obstacle to high speeds, because we use a smooth envelope, and of sufficient resistance in itself as to suppress all need of netting which would indent it.

With our apparatus we can also drop projectiles without any

troubles ensuing. Experiments made at Toul have shown that the aiming was not difficult when discharging projectiles of a determined shape. Further, the metallic construction of our cars makes it possible to carry weapons of the reaction-tube type and fixed firearms of the mitrailleuse pattern. No difficulties need be apprehended from lightening dirigibles of the weight of heavy projectiles; thus, if it is required to let fall a projectile weighing 100 kilogrammes at one discharge without altering the altitude of the airship to any extent, it is sufficient to cause the fan of the smaller balloon to work for 100 seconds, this increasing the weight of the balloon at the rate of one kilogramme per second. If the pilot should deem it immaterial whether the balloon rises or not when the projectile is released, he need do nothing, and the valves allow the escape of gas to take place sufficiently rapidly to prevent the internal pressure from increasing, and the balloon from bursting. Accidents have, after all, some advantage, and that which occurred to the "Patrie" affords a case in point. On leaving Verdun it was lightened by the removal of 750 kilogrammes (1,650 lbs.) of stones, and it rose to over 2,000 metres (6,500 feet) without bursting, although there was nobody in charge to work the valves.

The dirigible balloons manufactured on the type I have described attain a speed of 11·5 to 12·5 metres per second (40 to 45 kilometres = 26·5 miles, per hour); they carry 6 to 8 persons; 600 to 700 kilogrammes (1,450 lbs.) of ballast; 300 to 400 litres (80 gallons) of petrol. They can remain in the air for 10 to 12 hours and cover 400 to 500 kilometres (280 miles). They can go from Cuxhaven-Hamburg to Berlin and further, and can reach an altitude of 1,500 to 2,000 metres.

Results obtained.—The first trials, which were made in 1902, were successful from the first.

In 1903 and 1904, our pilot, M. Juchmès, made the first geographical journeys ever accomplished in a dirigible balloon; for instance, from Moisson to Nantes and return; Moisson to Paris (Champ de Mars), &c. Excursions were made at all hours, and even by night, and in almost every kind of weather, in rain, frost, snow, fog, in which trips Mrs. Lebaudy took part with Messrs. Lebaudy.

In 1905, our crew, accompanied by officers of the Corps of Engineers, made a long trip in three stages from Moisson to

Chalons, and then the dirigible was installed in the fortifications of Toul (the first to own such a craft), which proved its capabilities from a military point of view by scouting operations, by delivering sham projectiles, and by reaching the altitude of 1,375 metres (4,500 feet). It took on board the Minister of War, Generals, &c.

In 1906, the "Patrie" was constructed and delivered to its military crew, which navigated it from Moisson to Chalais-Meudon.

In 1907, during the summer, operations were carried out for training fresh sets of men, and during these Mr. Clemenceau, the Prime Minister; General Picquart, the Minister for War; Messrs. Messimy, Cochery, Grosdidier, Members of Parliament, &c., took seats in the car. A trip was made from Meudon to Rambouillet to show the dirigible to the President of the Republic. It also appeared and navigated at a stated time at the Longchamps Review on 14th July, within sight of the President, of the foreign visitors and of the Paris population.

In the autumn the "Patrie" made trips between Meudon and Etampes; Meudon and Fontainebleau. Manœuvres at great altitudes were carried out in combination with troops, and above the fortifications of St. Cyr.

In November, 1907, the two dirigibles, "Lebaudy" and "La Patrie," had made 123 ascents, and had carried sixty-five different persons; in the course of these ascents there occurred various trifling incidents, but no serious accident, and no single accident to any person. On 23rd November, 1907, the "Patrie," worked by three officers of the Corps of Engineers and two drivers, made the finest trip of 1907, from Meudon to Verdun, a distance of 250 kilometres (156 miles) in 5 hours and 45 minutes, in an unfavourable SSE. wind, without stop, and reached its above final destination in good condition.

It is, however, decreed that excessive good fortune must be paid for. Eight days later the "Patrie" was no more. In the course of an ascent of a most simple nature a series of adverse circumstances which will be prevented in future, resulted first in an unforeseen landing, and on the evening of the following day the balloon started off without its pilot. Twenty-four hours later it was careering along at the mercy of the wind which it had so often mastered; it touched Ireland, and later fell between

Ireland and Iceland in the ocean, where it is perhaps still floating. This accident, which led to the loss of the "Patrie," has by no means discouraged us, and we are still at work. In May next the dirigible "Republique," a sister balloon to the "Patrie," will be completed, and in the course of the present year we shall build others of improved types and of still greater power.

Conclusion.—The impulse has now been given; it dates more particularly from 14th July, 1907, and dirigibles are now being experimented with in England, France, Germany, Italy. Armies will soon be provided with such machines, which will add considerably to their effectiveness. Special progress is being made in France, and I beg to point out to you the very interesting ascents made as early as last February by our Vice-President, Count de la Vaulx, with a dirigible in which the propeller is admirably located. I should also point out the operations of last autumn, made by the dirigible "Ville de Paris," of M. Deutsch, which was taken in a very able manner to the French frontier by the engineer-in-charge, Mr. Kapferer, in order to replace the "Patrie." All these French military balloons are the natural outcome of the able experiments and demonstrations made since 1884 and 1885 by Captains Krebs and Renard, and of the sporting feats of 1900 to 1903 of Santos Dumont.

Overland and oversea, dirigible balloons will take up both scouting duties and the attack. Overland, they will navigate over the fronts of two armies; they will make it possible to follow the movements of armies and to attack their more important elements, the staff posts, ammunition depôts, and so forth. Oversea, their action will be of a formidable nature. Imagine a fleet of battleships accompanied by squadrons of light and fast ships, carrying dirigible balloons and provided with the means of supplying the latter. The balloons will be able to follow or precede the fleet at a high altitude, will signal the approach of the enemy, and will be able to attack him from above. Take, for example, the case of a fleet held back in the North Sea at the entrance to the Baltic by fortifications in the Danish Straits, the balloons of this fleet could hold the fortifications in contempt, could cross them and be able to cause terms to be dictated, if need be, right in the inland capital city itself.

In short, their action is likely to be a most powerful one in warfare, and it will be, in the first place, humanitarian.

DESCRIPTION OF A NEW LENTICULAR AIRSHIP.

By M. Louis Capazza.

Gentlemen,—The well-known manufacturer of motor cars, Mr. A. Clément, has entrusted me with the construction of an apparatus for aerial navigation, which will be called the "Bayard." It will be a soaring machine, and it is so described to distinguish it from dirigible balloons, and from flying machines. It will, however, act at times both as a dirigible and as a flying machine. Its real aim, however, is to progress through the air by a series of wave motions. Professor Marey has stated that gliding of this nature can only be carried out after speed has been obtained. This machine will fulfil the conditions put forward by Marey.

The machine is totally different from all others. It will be lenticular in shape, with the thickest part about one-third from the leading edge and flattened towards the rear.

Its dimensions are to be:—

Horizontal diameter ...	52·096 m. (171 feet).
Height, or double versed sine	8·717 m. (28·6 feet).
Length measured over surface	53·058 m. (174 feet).
Volume	9413·2400 cu.m. (332·429 cu.feet).
Area of top surface of lens ...	2190·776 sq. m. (23578 sq. feet).
Area of horizontal section of lens	2131·261 sq. m. (22943 sq. feet).
Area of "amidships section" ...	304·047 sq. m. (3272 sq. feet).
Top fin	80 sq. m. (861 sq. feet).
Lower fin	80 sq. m. (861 sq. feet).
Vertical rudder	26·500 sq. m. (285·3 sq. feet).
Horizontal rudder ...	26·500 sq. m. (285·3 sq. feet).

The wing surface, comprising the rear portion of the "lens," fins, and rudders, will be 2,856 square metres (30,744 square feet). The car, carried at 8 metres (26·2 feet), beneath the "lens" has a rounded front, 4 metres (13·1 feet) in diameter, and a rectangular body 15 metres (49·25 feet) in length, and 2 metres (6·56 feet) wide. It is connected to the "lens" by a steel cable suspension device, as recommended by Dupuy de Lôme. The car is built of steel tubes and will be fitted with two 123 H.P. motors in front, and one motor of the same power at the rear. Each motor is to drive a propeller of 2·80 metres (9·2 feet) diameter. The two propellers in front are placed one to the

right and the other to the left of the car, and 1·50 metre (4·92 feet) from the "lens." The rear propeller is in the centre line of the car and at 1 metre (3·28 feet) from its flooring.

The lenticular shape is maintained by internal partitions where necessary, and the small pilot balloon is partitioned in the same way. The suspension fixtures are attached at the partitions. Nineteen parallel rings formed of steel tubes ensure permanency in the shape of the "lens" in a horizontal direction.

The "Bayard" is to be inflated in the same manner as an ordinary spherical balloon. Its shape and construction allow it to be anchored down by one fixture alone, as in the case of kites. The lifting power of hydrogen, reckoned at the rate of 1·1 kilogram per cubic metre (14·5 cubic feet per lb.) will give the machine a lifting capacity of 10,360 kilograms (10·36 tons). It will weigh, with six passengers, 5,500 kilograms (5½ tons). There will thus remain 4,860 kilograms (4·86 tons) for ballast.

DEVELOPMENT OF THE AEROPLANE.

BY CAPT. FERBER.

MR. PRESIDENT AND GENTLEMEN—

On Monday, the 13th of last January, Mr. Henry Farman astonished the world by a triumphant demonstration that man was capable of flight—that with a machine heavier than air, he could set out from a given point, perform evolutions in the air, and return again to the starting place. Thus he realised a dream which has occupied the minds of men in all ages.

How, it may be asked, was such a wonderful practical result obtained, and almost without funds? It was not brought about by scientific calculations, but was due to three causes, moral, sporting and commercial, which I shall point out, and which have permitted the application of a fairly safe method of experiment, first employed by Lilienthal. This method consists of taking one's position in the machine, trying it as near the ground as possible, correcting the defects observed, and repeating the process until satisfaction is obtained.

The three causes to which I have referred are as follows. Firstly.—The aviator received the moral support of the

sympathetic atmosphere created by the presence of men, all of whom were familiar with the subject, and who for over two years had been convinced of the possibility of success. Secondly.—Flight was achieved by an apparatus designed by Voisin, who was my first pupil, and who, confident that the problem of aerial flight would be solved, had had the hardihood to establish two years previously, the first flying machine factory in the world. Thirdly, and lastly, flight has been achieved, because Levasseur, also knowing that the flying machine problem must be solved, had by 1903 sought and found the light Antoinette motor.

It was on this account that mechanical flight was realised first in France, and had Farman failed or vanished on the 13th of January, ten aviators would have replaced him in a short time, working on the same principles and by the same methods.

It is not possible for a great discovery such as the one in question, to be made entirely by one man. Quite a number of favourable circumstances are necessary. There was Lilienthal, in Germany, who by 1891 had shown the way to learn to fly ; he was made fun of because hardly anybody was capable of understanding his work. In America, there were men like Chanute and the Wrights who have guided us, but being too isolated they have been ill-advised, and wishing to retain everything have lost all. You have also had in England enlightened men like Cayley, in 1809, Henson, in 1843, Sir Hiram Maxim, in 1896, and Pilcher, in 1899, but working by themselves, even with sufficient money, they have failed to succeed.

In France, the man who rendered public opinion favourable, without which fruitful work is impossible, is unquestionably M. Archdeacon, thanks to his enthusiastic speeches, numerous writings and handsome prizes. It must be confessed also that he was assisted by the French characteristic of ardently attempting to realise the dreams of the future, such as are so admirably treated by your famous author, Mr. H. G. Wells. The sensations produced by being in an aeroplane could not be better described by any one, and what he has written is the more remarkable seeing that it appeared in 1898.

In this sympathetic atmosphere have been working and are still at work, always on the same lines, firstly the Comte de la Vaulx, who is with us to-night. He has made a most interesting aeroplane according to the designs of the well-known engineer

Tatin, who would have been able to drive an aeroplane a long while ago, had he been able to procure the necessary funds. But alas! as we aviators often remark, "It is much easier to make a machine that will fly than to 'raise the wind' for it." However that may be, the aeroplane I have mentioned did raise itself in the air, but the failure of a wing resulted in an accident which might have been serious and which has delayed the experiments.

After the Comte de la Vaulx, comes Esnault Petterie, who has done something original, having himself invented the motor and devised a very practical method of starting. At the end of each wing he places a wheel, and beneath the centre line two supporting wheels. At starting it leans on one side-wheel, then as the speed increases, it rights itself, and runs on the two central wheels until it rises from the ground. This aeroplane is very graceful, but it seems somewhat lacking in power and longitudinal stability.

We next come to M. Blériot, who has been an enthusiast for many years, and who has constructed no less than seven machines. One, in 1900, was of the aviplane type, the second, in 1905, was built by Voisin, like that of Farman. The third, similar to the previous one, was tried on the Lake d'Enghien, without success, with two Antoinette motors, of twenty-four H.P., driven by Voisin. The fourth, similar to Farman's model, was broken at Bagatelle in 1906. It was driven by Peyret, an old soldier, formerly under my command.

Real progress commenced in 1907, because then, instead of employing hired drivers, the inventor commenced to drive the machines himself. I often say, in fact, that the drawings and calculations of a machine are nothing; the difficulty begins with the construction, which necessitates the devising of a multitude of details, but this difficulty even is nothing in comparison with that of learning to manage the machine.

Blériot succeeded in raising himself with No. 5 machine, but it lacked stability. With No. 6, he first employed 24 H.P. Antoinette motors, then 50 H.P. motors, and also raised himself, but the instability remained. One day he travelled 18 kilometres (11·2 miles), but fell from a height of 25 metres (82 feet). However, with No. 7 machine, he flies at the present time at the rate of nearly 80 kilometres (50 miles) per hour.

Santos Dumont at first was merely a balloonist, but after the

considerable sensation caused in 1905 by the Wright brothers—and it may be remembered that this was solely due to the documents which I possessed and published at that time—he felt that the time had come for flying machines. Like all balloonists he started with helicopters, or lifting screws, but it was not long before he saw the great difficulty of the problem and wrote to Levasseur, who advised him to take up the aeroplane. Nevertheless, he made the mistake of putting in front of the aeroplane that which should have been behind, and it really required all his skill to cover 220 metres with this machine. He did not repeat this performance, and last February his aeroplane got broken on a windy day. Then he abandoned the aeroplane for some time and took up the question of the hydroplane, in the endeavour to realise a speed of 100 kilometres (62·1 miles) per hour on the water. He thus lost time, and when, the other day he wished to catch up Farman—with rational aeroplane this time, but too small—he was only able to accomplish very short flights.

Let us now consider Farman's aeroplane, and try to understand the progress of his trials. During the month of September he studies the motor, and learns how to drive it, working every day with an admirable care and persistence. The 30th of September he flies for the first time, the length of the flight being 80 metres (87½ yards). It is only on the 26th of October that he succeeds in flying in a straight line; that day he accomplished 770 metres (840 yards).

He had noticed, the day before, that the machine kept on trying to rear up, and for this reason it lost speed and fell. To prevent it from rearing, he had only to turn the rudder towards the earth—that was what he learnt on the 25th of October. Still he had to learn to turn, and that he managed last January, after having lightened his machine and lessened its resistance by eliminating part of the hinder cells. By 10th January, he had learnt to lean over freely towards the centre of the circle when turning, after the manner of a bird, and on 13th January, he easily won the prize of 50,000 francs.

Having done justice to the driver, we may now refer to the constructor, Voisin. After a popular lecture which I delivered at Lyons, in 1904, a bright and intelligent young man came upon the platform and said to me "I have understood the method which you teach, and I mean to devote myself to it." The next

day he left for Paris, and entered the service of M. Archdeacon as aviator, thus becoming the first man in the world to earn his living as an aeroman. They were at Berch sur Mer with a machine and in considerable difficulties. On the receipt of a telegraphic request, I went there and showed Voisin what I had learnt in three years' work with the apparatus of Chanute and Wright. He understood, and we succeeded in making flights of about 20 metres length.

He then made for M. Archdeacon a large aeroplane of the Hargrave kite pattern, but fitted with an elevating rudder, the usefulness of which I had shown him, having learned it myself from Wright.

It has been this type of aeroplane which Voisin has always reproduced with an admirable obstinancy, in spite of all difficulties. He first tried it for M. Archdeacon in 1905, towed like a kite, on the Seine by the racing boat Antoinette. He tried it again for M. Blériot under the same conditions a few days afterwards, but there was an accident, the machine overturned, fell in the Seine, and Voisin remained twenty seconds under water. We all thought him drowned, the time seemed so long. This experiment, among others, served to show that an aeroplane propelled by a force of from one-third to one-quarter of its own weight, will rise with certainty.

After this, M. Blériot associated himself with Voisin and founded the first aeroplane factory. At the beginning of 1907 Voisin was sole proprietor, and he placed himself at the disposal of all inventors. That enabled him to live and to await the coming of someone who would trust him and would order an aeroplane capable of flying without imposing his own personal ideas on the design. The first to present himself, fulfilling these conditions, was M. Delagrange, in February last. Voisin made for him the well-known type and fitted it with an Antoinette motor. On 30th March, 1907, this machine flew 60 metres (65·5 yards). There can be no doubt that if M. Delagrange had taken the thing in hand, driven it himself, and acquired the familiarity that he is only now seeking, he would have been the first to arrive at the final result. The second purchaser who put confidence in Voisin was Farman, who went to him in March last, and you know the rest.

You have seen that Voisin trusted at the outset on the ideas

and the method which I professed. Whence came these ideas? I had noted the experiences of Lilienthal, and contrary to the majority of people, who believed that he made experiments with a parachute, I realised that they were really flights, and that this man had found a way to learn flying which ought to lead to complete success, for it allowed of comparatively safe experiment and of continual repetitions.

I considered it my duty to repeat these experiments and to popularise them, in order that this great invention might first be born in my own country. I am glad that this has happened, as I hoped. (*See illustration, page 297.*)

You have also had in England a man who understood the matter in the way which I did, and who was capable of obtaining the final result. Unfortunately for you, this man met his death in 1899 in an experiment. His name was Pilcher, and it is only right to render him justice.

In America, another man understood the question in the same manner. I refer to Octavius Chanute, and we must also do him justice, for with entire disinterestedness he told all he knew to those who wished to work at the subject. He has trained two remarkable pupils, the brothers Wright, whose works, published up to 1903, have assisted my own progress. You have heard how I borrowed the idea of the lifting-rudder and taught Voisin the manipulation of it. We must also tender them their due, although pitying them for not having understood that there is no secret in a flying machine, and that the skill required to drive it is not worth a million. But we should perhaps excuse them, because, blinded by a great and legitimate pride, they have believed, as they have often told me in letters, that they were ten years ahead of other workers.

However this may be, in 1901 I repeated Lilienthal's experiments, and from the commencement of 1902 the experiments of Chanute and Wright, which have led me to the knowledge of very stable designs, and of rules for management, which I have made public since in writings and discussions.

It is thus that I have demonstrated by 260 aerial glidings that landing presents no difficulty provided that one can arrive tangentially to the ground, the machine then running along the ground at full speed.

As regards calculations, these do not need to be numerous—I

have published the complete mathematical theory of the aeroplane, and I may say that I have employed the principles enunciated by your compatriot, Prof. Bryan, of Bangor University —but, in brief, to design an aeroplane it is sufficient to make use of certain formulas.

The first corresponds to the formula for resistance of the air, given by Duchemin, this being the most suitable—

$$K\,S.\quad V^2\,Sin\,\theta. = P$$

where θ = the angle of impact; S the area of the surface in square metres, V, the velocity in metres per second; and P the pressure in kilogrammes. In practice, however, as θ is difficult to measure, we write, for simplicity—

$$K^1\,S\,V^2 = P$$

where $K^1 = 0{\cdot}06$.

You may notice in comparing this result with that of the table given by Mr. Herbert Spencer, and which is the only one generally admitted, that it is about eight times more favourable. It is for this reason that, contrary to general belief, it is fairly easy to make an aeroplane fly.

The second formula is—

$$F = \frac{P}{m}$$

where F is the tractive force necessary to maintain an aeroplane in horizontal flight; P the weight in kilograms, and m a co-efficient which may vary from 5 to 3 in value. If it is taken as equal to 3, there is no doubt whatever of making the aeroplane rise from the ground, but this result is still very probable when 4 is taken as the value of m.

It follows that the work done (in kilogram metres) is theoretically $F\,V = \frac{P.V}{4}$ and the H.P. (continental) required is $\frac{P.V}{4 \times 75}$ or, taking 50 per cent. as the prospective efficiency, H.P. $= \frac{P.V}{150}$

The third and fourth formulas are those of the screw propeller, which I gave in 1906. We have

$$F = a\,h\,r\,n^2\,d^4$$
$$T = (\beta\,h^2\,r + \beta^1)\,n^3\,d^5$$

where F is the pressure in kilos, T the work in kilogram-metres, n the revolutions per second, d the diameter in metres, h the ratio of the pitch to the diameter, r the slip of the screw, and a, β, β^1 co-efficients depending upon the screw employed.

In many of the screws used in our aeroplanes, the co-efficients have the following values—

$$\alpha = 0{\cdot}033,\ \beta = 0{\cdot}027,\ \beta^1 = 0{\cdot}003.$$

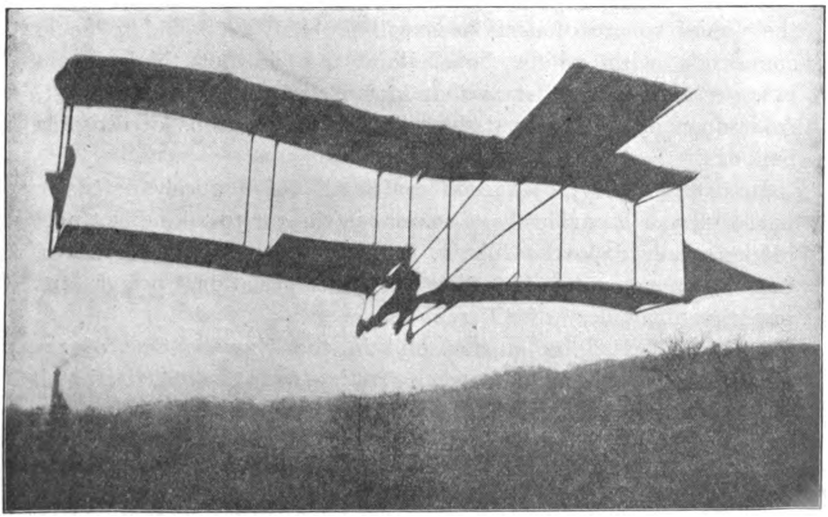
Finally, the last formula is the definition of the slip (r), and we have—

$$r = \frac{n\,h\,d - V}{n\,h\,d}$$

These formulas are sufficient to deal with any type of aeroplane that may be desired.

I ought to point out, finally, that the cellular form of the heavier-than-air machine, which is used at present, and which was introduced into France by my influence, is a bad solution, because it presents great resistance to forward motion. It is not the French solution—the French solution being that which Penaud indicated in 1868, and which he exemplified in model form with an indiarubber driving spring. His model is monoplanar, and approaches very nearly to the form of a bird, there being a long tail for steadiness, and rudders behind.

Now that the possibility of solving the problem is demonstrated we are all going to apply ourselves to the solution which is theoretically the best; but I believe, however, that I did not do wrong in trying first to realise that which already worked well elsewhere, for one must always take what exists in order to improve it afterwards.



Capt. Ferber on his Aeroplane No. 5, Dec. 12th, 1904.

"THE FUTURE OF AERONAUTICS."

BY COUNT HENRY DE LA VAULX.

(*Vice-President of the Aero Club de France.*)

You have just listened to two learned communications made by my distinguished colleagues, M. Julliot and Captain Ferber, on dirigible balloons and on flying machines ; they have given you data on the technical aspect of aeronautics and details of the results obtained in France by our aeronauts and our aviators.

In view of these results, and they are actual results, it is interesting to inquire as to what will be the future of this new science and what are the practical ends which can be served by automobile flying machines.

I have had the opportunity of experimenting personally with the various types, both with those lighter and with those heavier than air, and my object in coming before you is to endeavour to show you as clearly as possible the fields of usefulness which this new branch of industry may be expected to occupy in the future.

Besides the spherical balloon, a simple and beautiful apparatus for investigating the higher atmosphere, for meteorological, astronomical and physiological researches, the dirigible balloon and the flying machine will both contribute to a considerable degree to the evolution of knowledge.

Dirigible Balloons.—In the first place, dirigible balloons, I take it, will soon be made in gradually increasing dimensions, and their chief sphere of usefulness will probably be found to be in connection with military operations. I do not think I am exaggerating when I state that in five years' time at the most, from now, all the great nations will own squadrons of dirigible balloons.

In my opinion these aerial craft will act a purely defensive part ; they will enable the observers in the car to take exact note of the ground below, to obtain most minute particulars concerning the movements of armies, and the situation, power and quantity of artillery of different kinds.

They will also be most useful in the Navy. One of the advantages of the balloon, when floating over the sea, is that it is possible from such a position to discover objects below the water surface. Thanks to this, an aeronaut will be the eye of a fleet, and will warn the latter of the approach of submarines.

Contrary to what has been said repeatedly and to statements made in technical publications, I cannot realise a balloon taking the offensive and carrying for this purpose a number of projectiles. It has been said that the projectiles by being allowed to drop from a balloon, and not requiring to be expelled from a gun, could be of reduced weight (a maximum of 10 kilogrammes —22 lbs.—has even been suggested), formed of pure explosive material, surrounded by a thin metallic envelope or can.

On the basis of this theory balloons have been pictured carrying one hundred to two hundred bombs and strewing devastation and destruction in their paths. In holding up these advanced views it would seem that the question of assuring oneself on the matter of the efficiency of such projectiles has been lost sight of.

I believe, however (and in this I think I share the opinion of your President, M. Canet, who is most familiar with these questions), that such projectiles would have no destructive effect. The force of a projectile proceeds mainly from the thickness and resistance of the metallic envelope surrounding the explosive, which, under the action of the combustion of the powder, is burst into hundreds of pieces, the more violent the powder the further these are driven. It would therefore be necessary for the projectiles carried "on board" to weigh each from 200 to 300 kilogrammes (440 to 660 lbs.), in order to obtain a recognised standard of efficiency. But a balloon of 5,000 to 6,000 cubic metres (175,000 to 190,000 cubic feet) could only carry four or five such projectiles at the most. This would mean the sacrificing of a great weight to chance.

Besides applications in warfare, I believe dirigible balloons will find a place in sports, and those lucky men who now purchase a yacht will probably later on purchase a dirigible balloon.

In voyages of exploration also, there may arise circumstances in which dirigible balloons will render great service, such as, for example, in the crossing of countries difficult of penetration by the ordinary means, and deserts without water, and where facilities for renewing the supply of provisions are lacking.

The above will, I believe, be the only possible ways in which dirigible balloons can be utilised, and apart of course from unforeseen scientific discoveries, such as the discovery of a gas having a phenomenally high lifting power, they will never become commercial carrying machines, nor universal travelling

conveyances. Their high cost (300,000 to 500,000 francs = £12,000 to £20,000) and the large installations on land they require, will necessarily limit their utility, and Governments and very rich sportsmen alone will be able to own them.

Flying Machines.—The practical usefulness of the dirigible balloon is now an established fact, and the services it can render are well known; this cannot yet be said as regards the flying machine.

The progress made during the last year in regard to the latter is very great, and further rapid progress may be expected. In the matter of cost, flying machines are the reverse of dirigible balloons; the latter represent veritable fortunes, while flying machines necessitate only limited expenditure, and for this reason a large number of engineers, small capitalists, and sportsmen who are debarred from using dirigible balloons can embark on the study of the flying machine. Proof of this may be seen in the existing number of both kinds of machines. The number of dirigible balloons manufactured during a long period of years amounts to less than twenty, while the flying machines built during the last two years exceed fifty in number.

From the multiplicity of the attempts made in aerial navigation with a machine heavier than air, excellent data have been obtained of assistance in the solution of this problem; emulation has also come into play, with the result that flying by aeroplanes which a year ago was practically non-existent, has now become a veritable sport, and one of a most fascinating nature.

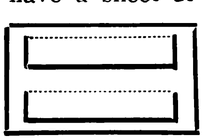
The sportsmen who endeavour, on specially selected grounds, to fly the longest distance and to turn about in the boldest possible style, become every day more numerous. There is, therefore, one primary point in its favour, that of encouraging a sport in which all the physical and intellectual faculties of man may be developed.

What is the future of flying by aeroplanes? Only suppositions can be made, and I believe that for a long time to come it will remain in the domain of pure sport, without attaining to commercial usefulness, or usefulness in warfare. But even in this one sphere of sport it has immense progress still to make, and this it will make, I feel confident, and I should not be surprised to learn that in five years time flying machines will have covered,

over immense plains, distances of 200 kilometres (125 miles) at a height of probably 30 metres (95 to 100 feet) above ground level.

Such are, gentlemen, my opinions as regards aerial locomotion by both the lighter and heavier machines. That events may prove that I have been mistaken, and that still better results will be obtained than those I have here forecast, is no doubt the sincere wish of all present.

MAJOR BADEN-POWELL, after referring to the satisfaction it gave him to see so many distinguished foreign authorities present, said "at this late hour I can hardly go into a criticism of all the details of this paper, but I should like to refer to one matter which has an important bearing from a practical point of view. I have made some study of aerodynamics for a number of years, but I must own that the data we have are so meagre, and such laws as are laid down so uncertain, that I have received very little assistance from theory in designing practical flying apparatus. From what Mr. Chatley has said, and indeed from what is generally understood, we must take it that an aeroplane is a plane surface inclined at a positive angle to the horizontal, that is, has its front edge raised in an upward direction. This, propelled forward, causes the air to impinge on its under surface and thus gains an upward thrust and supports itself on the air. This is the general principle on which we are told we must construct our airships. The author has referred to Langley's apparently paradoxical discovery that a plane, when perfectly horizontal and propelled rapidly forward, does not sink. Now I go a bit further. I maintain that if the plane be set at a negative angle, that is with its front edge sloping downwards, it still gets buoyancy when driven horizontally. One is apt to say at once that this is absurd, that the air striking against the upper surface must tend to drive the whole downwards. Well, I can show you a very simple experiment to prove my point. Here I have a sheet of stiff paper with two panels cut round on three



sides and bent back (along the dotted line). A small weight is added at the bottom. Viewed from the side, this will then appear thus :—

Now I hold this up and let it drop vertically, what will happen? Think of your theories. It seems simple enough. The air catching against the projecting

panels must cause the plane to tilt and the whole will fall inclining towards the side on which the panels project. The centre of pressure, from all we have heard, will advance towards the front edges, causing the apparatus to tilt still more, till it turns horizontally and glides with the inclined planes uppermost. But now, on letting it drop, you will see that this is exactly what does *not* happen! It drops vertically for some distance, then turns away suddenly and glides horizontally, but in *the opposite direction* to the projecting flaps, and continues to glide with the planes *inclining downwards*. This, it seems to me, proves that the resultant of the various air pressures is in a direction towards the side opposite to the planes, or in other words, that these inclined planes cause the air to press with greater effect on the lee side than on the windward side. I have tried a number of variations of this experiment. The paper border has nothing to do with it, as the inclined planes may be mounted on sticks, and exactly the same result always ensues. I have made propelled models on this principle, which travel through the air with great stability. I call them 'dipping' planes."

THE HON. C. S. ROLLS, M.A., of the Aero Club, remarked that Mr. Chatley had said little in his interesting paper concerning the "lighter-than-air" side of the question, but, in his (Mr. Rolls' opinion) this form of airship, *i.e.*, the dirigeable balloon, was destined, for military purposes at any rate, to play a leading part for many years to come, on account of its superior weight-carrying capacity as compared with the aeroplane.

The author had mentioned some of the difficulties connected with this form of machine, but there was also an objection he had not alluded to. He (Mr. Rolls) had recently been fortunate enough to make a voyage in the airship "Ville de Paris," which had since replaced the lost "Patrie," and he was much struck with the apparently helpless position that one of these airships would be in in the event of the engine stopping, when anything like a strong wind was blowing. As soon as the engine stopped the airship was, of course, converted into an ordinary balloon, but with this difference that with the ordinary balloon one had a flexible wicker-work car which protected the occupants, and which stood any amount of knocking about, whereas the dirigeable balloon, of the "Ville de Paris" type at any rate, had a long rigid framework of metal tubes or stiff wooden rods,

and when effecting a landing without the aid of a motor it seemed to him that there would be a great risk of throwing out one or more of the occupants, and also of breaking off some of the frame-work or machinery. This latter point might also, of course, occur in the air owing to the fracture of a casting, &c., but when such a thing happened the sudden release of weight would cause the airship to rise rapidly, and it would probably attain a considerable height even though the valve were held open. The result would be that the second time it would descend with much greater velocity than the first, and might hit the ground with a still more severe shock, another occupant might be thrown out or another part broken off, and the same rapid rise and fall would happen over again.

In regard to the aeroplane side of the subject, the principal difficulty with machines of the Farman type was the overheating of the engine; the limitations of weight were such that very little cooling water could be carried, and there was a very small radiating surface; the engine ran at full speed and became hot in a few minutes, so that Mr. Farman was never quite certain when he was coming down on to the ground again.

Another difficulty that would have to be reckoned with, in the course of time, when aeroplanes were capable of long distances, was the personal element, *i.e.*, the great strain that the manipulation of one of these machines entailed upon the operator. With the Farman type of engine there was no carburretter, no throttle, and no variation of ignition, consequently, the whole attention could be given to the steering and balancing, but it would be admitted that for an aeroplane to be of any practical use it would have to be possible to vary the speed of the engine; and with machines of the Wright type where this was done, one had, firstly, the two kinds of steering—the vertical steering and the horizontal steering—and the balancing; but in addition to this there were also the adjustments of the carburation, throttle, the timing of the ignition, the lubrication, and so forth, so there was a great deal for the operator to look after, and his mind and body would be in a great state of tension all the time. Indeed, one of the Wright Brothers had told him (Mr. Rolls) that it might be possible to produce an aeroplane that would run 100 or 200 miles before it would be possible to find an operator who could work it.

In regard to what the author termed the "Aviplane" or flapping wing variety, it was obvious, of course, that when any substantial weight had to be dealt with, such as the supporting of an engine, it would be impossible to construct wings which would be strong enough at their fulcrum to withstand the strain due to the great leverage, and this was evident in nature, for when one came to think of it, there were large and heavy creatures to walk on land and large and heavy creatures to swim in the sea, but there was no instance of a really large and heavy bird that could fly in the air, and nature had also shown that it would be impossible to introduce a revolving propeller shaft into the interior of a bird without seriously interfering with its digestive organs!

On the question of the dropping of explosives from airships, in his recent voyage in the "Ville de Paris," when passing close to a fort, he was much struck with the great ease with which it seemed it would be possible to discharge a bomb and blow up the fort, although the occupants of the airship would probably have blown themselves up at the same time. He thought an excellent idea was suggested by Mr. Gaudron in a recent paper on the subject, namely, that an explosive might be let out on to the end of a wire a thousand or two thousand feet long before discharging it, for this would enable a much more accurate aim to be taken, and it would also enable the airship itself to be more out of the range of guns.

The author had referred to the prohibition of the use of explosives thrown from airships. He (Mr. Rolls), however, believed that the position was this: some years ago it was decided by International Conference that the discharging of bombs from balloons should be prohibited from civilised warfare, in the same way as were chain shot, expansive bullets, and the like; but the measure was only a tentative one, to hold good for five years. This period came to an end last year, and when the Convention met again, several foreign countries, who had spent large sums of money on airships, voted strongly against the prohibition remaining in force, although Great Britain was in favour of leaving things as they were. The powers were, therefore, now free to add this new terror to warfare. France and Germany were fast forming fleets of aerial warships, and it was very important that this country should not be left behind. In fact,

it seemed to him that it was a matter which, if neglected for too long, would ultimately affect the safety of the nation.

He wished to say in conclusion, that he was very pleased to see present his friend Count de la Vaulx, whom he had known for many years, and under whose guidance he had made some of his earliest balloon ascents. The Count was undoubtedly one of the leading authorities on aerial navigation in the world, and he was sure they would all congratulate themselves upon having him, M. Julliot, and the other distinguished French gentlemen at their meeting.

DR. H. S. HELE-SHAW said: I am glad to take this opportunity of paying a tribute to the work of a distinguished Frenchmen, Professor Marey, on the movement of a current of air when striking plane surfaces placed at various angles. Professor Marey gave an account of his experiments before the Academie de Sciences, and on the same occasion and by his invitation I myself described my own method of dealing with corresponding phenomena in liquids. The account of Professor Marey's experiments will be found in Comptes Rendus, 1901, and his method consisted of an ingenious arrangement of about sixty small tubes, by which smoke was allowed to come in stream lines against plates in various positions and with different velocities of the jets. In this way a clearer insight was obtained into the behaviour of air both in front of and behind a plate, such as could not be arrived at by any other means. I recommend some of the younger men present to follow up this method, as it seems to be capable of very great development. As an instance of its use I may say that if the reader of the paper had seen these experiments he would never have drawn the diagrams which he had shown on the lantern screen that night, giving the centre of pressure on an inclined plate nearer the edge farthest from the approaching stream. As a matter of fact the point is always to be found on the other edge, and on theoretical grounds I do not know any circumstances under which it could be otherwise. I am glad to emphasise what Major Baden-Powell has said as to the extreme complexity in the movements of the air. It may be said that in the present state of our knowledge no mathematical treatment has been devised for dealing with the complex effects produced by the movement of an

aeroplane at a speed resulting in unsteady motion (that is to say, vortex or whirlpool motion) of the air, and since this unsteady motion is found to occur even at quite low velocities, it is no wonder that so far all successful results have been arrived at by purely experimental methods. This is equally true of the airship, as of the aeroplane, and I venture to think that it will be a very long time before the problem of navigating the air will be reduced to the same, or anything like the same, scientific state as that of problems connected with the stability and propulsion of ships.

Nevertheless, one thing is certain, that the airship is with the latter problem equally amenable to natural laws, and there is one consolation in all this, that so far from having reached a state of finality in mechanical science we have in aeronautics a problem which even the youngest men present are not likely to see completely solved.

I venture to think that the meeting to-night, at which so many young engineers are present, and at which some of the best known French exponents of aeronautics have given their experiences in such an interesting manner, will be regarded as a red-letter day in the history of the Junior Institution of Engineers.

MR. R. H. PARSONS considered the Institution very fortunate in being honoured by the presence and assistance of so many distinguished men as were there that evening. That their friends from across the Channel, where so much had been done in developing aerial navigation, should have kindly come and joined with well-known Englishmen in giving the Institution the benefit of their knowledge and experience was a compliment most highly appreciated by all members. Turning to the subject of the paper, Mr. Parsons thought it rather late in the day to refer to the Sin^2 law as if it had any bearing on the question of the pressure of air on planes, for it had been discredited for over a century. It had been deduced from an entirely false conception of the nature of the atmosphere, by Newton, and the time had come for it to be forgotten. The assumption underlying it was that air behaved like an assemblage of distinct particles, any number of which could be moved without affecting the adjacent ones. The well-known phenomenon of the shifting of the centre of pressure on a moving inclined plane showed the fallacy of Newton's assumption, as did

also the experimental fact that the faster a horizontal plane was moved the more slowly it fell. There was, however, a limiting case in which the law probably held, but as it involved an infinitely long, thin, and narrow plane moving endways, it had no practical significance.

Would the author give his authority for the value of the constant in the formula for the pressure on a plane moving normal to the air = $\cdot 00166 \times \text{velocity}^2$, as this apparently differed considerably from that given by others, who, it should be stated, frequently differed largely among themselves.

The pressing need, the speaker considered, at the present time was to find some method of reducing the enormous wing-areas of flying machines. It was absurd that a machine only barely capable of carrying a man should be too wide to go down an ordinary street, and unless something could be done to reduce the overall dimensions, the outlook for the future was not very bright. The method of using superposed planes, first tried by Wenham, seemed to afford the most promise. Langley's experiments were generally held to prove that the minimum distance between such planes must be not much less than the fore and aft length of the planes. It was very probable, however, that by having supporting surfaces of true stream line form, and not planes such as Langley used, the distance might be greatly diminished. It was a curious fact that the blade of a Parsons' turbine was of almost the exact section found many years ago by Mr. Horatio Phillips to be the best for an aeroplane. The reaction turbine blade and the aeroplane had many features in common, the most efficient form and angles of both being dependent largely upon the conditions of stream line flow. A study of Mr. F. W. Lanchester's recent book on "Aerodynamics" would throw much light upon the action of air impinging on curved surfaces, and it gave physical reasons for many seeming anomalies. A proper understanding of the behaviour of air when meeting curved surfaces would assist both the design of supporting planes and propellers, and would almost certainly indicate the way to make flying machines more compact and efficient.

CORRESPONDENCE ON AERIAL NAVIGATION.

Mr. F. W. Lanchester wrote: I have read with much interest Mr. Chatley's paper on aerial navigation, a copy of which has been sent me by the courtesy of the President of the Institution. The fact that engineering societies are giving serious attention to the subject of aerial navigation may be taken as a fact significant of the change that has come over the spirit of the dream within the last few years.

There are several points on which Mr. Chatley's paper invites criticism, and others on which some elucidation appears to be required. It is with great regret that I find myself unable to accept the kind invitation proffered me to be present at the discussion, and under the circumstances I am placing my written remarks in as terse a form as possible in the hands of the President to deal with as he may see fit.

Firstly, a point of terminology occurs, and one that is of more than terminological importance. I refer to the use of the word aeroplane. The definition given by Mr. Chatley includes that anomolous article—a curved aeroplane, and notwithstanding the differences between the behaviour of plane and curved surfaces, he treats them collectively in the observation phenomena. It is, I think, preferable to confine the term aeroplane to a plane aeroplane, and to use some other word for a curved member; it is then more easy to define what one is talking about. This is the course I have adopted in my work on "Aerial Flight."[1]

From the "conditions" cited in the paper* (1) to (5), it would appear that a *plane* aeroplane is intended; otherwise (1), (2), and (3) do not of necessity apply. The "suction" on the back of the aerofoil[2] may also be due to the conformable flow of the air, as shown in chapter iv. of my "Aerodynamics," to which reference has already been made. The discovery of the fact that the aerial disturbance is of the nature of a wave, as stated in (5), is one that I myself made about the year 1892; I gave an account of my work in this direction at a meeting of the Birmingham Natural History and Philosophical Society in 1894, and made some further publication in patent specification 3,608, 1897, and recently a full account is given in my "Aerodynamics." It is

[1] I employ the term *aerofoil* to denote a supporting member of undefined form. From the Greek ἀέρος and φυλλοτ (lit. an *air-leaf*).

[2] See note [1] above.

*Page 271.

more correct to say that the aerial disturbances comprise a cyclic component, a term which will be understood better by those who have studied the subject of hydrodynamics. Mr. Chatley's conclusion (4) agrees with my own observations. I believe that the value of skin-friction is in practice between 1 per cent and 2 per cent. of the pressure on the same plane when moving normally, and I have shown in my work that skin-friction is a very important factor in the economics of flight. This view is, however, contrary to the conclusions of Dines, Langley, and Sir Hiram Maxim, and it is curious to find that Mr. Chatley himself quotes conclusions formulated by Langley, involving the assumption of the negligibility of skin-friction, without questioning them in any way. I have myself demonstrated that the late Prof. Langley's conclusions rest entirely on this one fallacy, and I have shown in my work, chapter x., that his experiments in nowise prove that which he states them to prove.

With reference to (2) and the diagram to which this refers. This diagram includes one case that relates to a parallel infinite lamina and not to a square plane at all. I refer to Lord Rayleigh's curve. This should not appear amongst the other curves shown, or if it does appear the words "square plane" should be deleted from the title; also it should plotted to a different maximum. Mr. Chatley can seen my meaning as to this by reference to chapter vi. of my "Aerodynamics," where these curves are correctly represented in their proper relationship. The same remark applies in a sense to Newton's curve. I have shown that this has reference only to the case of an infinite lamina in apteroid aspect, that is to say, with its finite dimension at right angles to the direction of flight. This curve is without meaning from an aerodynamic point of view in any other sense. I am sorry to find no special mention of the work of Dines in this connection; his experiments are of importance, and should have been included.

I note that as a rider to item (3),* Mr. Chatley states that the changes in the position of the centre of pressure *greatly complicate the question of balance.* Now nothing of the kind is actually the case. The behaviour of the centre of pressure in respect of changes of angle is actually the source of equilibrium of the ballasted aeroplane,[3] and of most of the variants of same,

[3] § 162 "Aerodynamics."
*Page 273.

as for instance, the paper gliders invented by Pline, Hele-Shaw, Weiss and others ; this is fully explained in my "Aerodynamics," section 162. This misleading statement appears again under the heading of "Balance." (*Page 276 of paper.*)

It is perhaps too much to expect that Mr. Chatley should have had any suspicion of the pitfall into which Langley had fallen, so that he must be pardoned for stating as Langley's paradox that which would have been better expressed by the word fallacy. Langley's conclusions would apply if the air were frictionless, but the influence of skin-friction entirely alters the conditions. On the basis of the neglect of the car or body resistance (as per Mr. Chatley's statement), the energy under real conditions is constant in respect of velocity from point to point ; that is, the power required varies directly as the velocity ; the assumption being that the machine is in every case designed for the smallest energy expenditure. This I have proved, both from theoretical considerations and as a deduction from experiment.[4]

I do not understand the paragraph as to the angle of the plane being reducible from 25° to 0°. As to the supporting power to be derived from a plane at 60 miles per hour and zero angle, this may be one of Langley's paradoxes, as stated, but it certainly is not true. I should like to know where in Prof. Langley's writings any statement to this effect occurs, for I do not recognise it at all.

I do not see on what grounds Mr. Chatley wishes to alter the name of a screw propeller ; how does he propose in his system of terminology to describe a *screw of true helical form* for example. Does he propose to say a *helix of accurately screw shape?* It is always dangerous to attempt to alter an established word. This is merely one of the difficulties that might arise.

In the remarks under the heading "Tractor Screw," Mr. Chatley omits to mention the main defect of a screw of this kind. This is due to two added causes ; firstly, the screw is unable to recover the wake energy, as is the case when it is placed abaft the "vessel" ; secondly, the vessel itself is situated in the screw race and experiences additional skin-friction on this account. (Compare "Aerodynamics," chapter ix.)

I do not know why Mr. Chatley gives the credit of the work of Mr. Levavasseur, of Paris, of the "Antoinette" to The Adams

[4] "Aerodynamics," chs. vii., viii., ix. and x.

Manufacturing Company. I believe Mr. Levavasseur was the initiator of the featherweight petrol motor, and he ought to have the credit for the results he has achieved.

In conclusion, I think that Mr. Chatley is to be complimented on his courage in placing before the Junior Engineers a paper on so intricate and treacherous a subject as aerial flight.

MR. A. W. MARSHALL wrote: I support the author's remarks in the second paragraph of his paper. However, notwithstanding the data which have been given from time to time by various mathematical investigators, an aeroplane or other machine of the heavier-than-air type will not probably be successful as constructed from the drawing office designs. There are disturbing effects which may quite upset theoretical determinations. For example, those caused by variation in wind velocity and the different conditions of the atmosphere near the ground and at even moderately high altitudes. Near the ground air currents are of an eddying nature, due to the unevenness of the earth's surface. Prof. Langley in his experiments upon wind velocities, found extraordinary variations during short intervals of time. The rate would vary in one minute from 30 miles per hour to zero, and then to 14 miles per hour; then again to zero, and back to 30 miles per hour within two minutes, with intermediate fluctuations of 12 miles per hour and so on. This is the kind of conditions which will affect seriously calculations based upon an assumption of steady pressures to produce lifting effects.

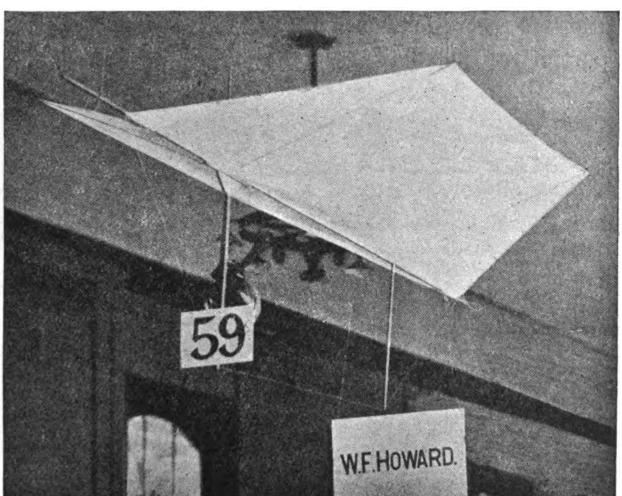
It is very questionable if flat aeroplanes will be of any real service. The remarkable experiments of Le Bris, in France,* with curved planes, including the wings of an albatross, and of Horatio Phillips in England, also with curved planes, appear to prove this. Phillips' conclusion, based on twenty-seven years' experimenting, was that anything approaching a flat surface is useless for supporting heavy loads. Referring to the author's remarks on this point, it may be mentioned that Sir Hiram Maxim found that with flat planes most of the lifting is done by the front portion; it would therefore appear that it is of little use to design long planes. If several small planes are placed tandem fashion, one behind the other, the same effect takes place, the front plane does the greater part of the lifting work. This seems

* "Progress in Flying Machines" by Chanute.

to be proved also by the behaviour of the recent aeroplane machines, which have achieved some success in actual flight. Also Lilienthal, in Germany, determined that flat planes offer unnecessary resistance. Phillips' experiments show that the thickness and shape of the cross section is of importance, a merely curved surface of very thin section being only a partial solution of the problem. Some of Maxim's planes carried 8 lbs. per square foot of surface, and Langley carried at the rate of 250 lbs. per horse-power with very small planes, but it does not appear to be possible to lift at the same rate as the planes are increased in size. I consider that the author's remarks in regard to construction should be modified where he states "the surfaces may be of silk or aluminium." To obtain the best effect the aeroplane surface must be absolutely rigid. Langley and Maxim have proved that the lifting efficiency falls as much as 50 per cent. if the shape of the plane is distorted by flexibility. Maxim carried at the rate of 100 lbs. per horse-power with small wood planes, but could only lift 40 lbs. per horse-power with large planes made of flexible material. For flight to be possible Phillips found that each square foot of surface must support at least 3 lbs. When designing an aeroplane the question of drift as well as lift must be taken into account; for the plane tends to go backwards as well as to rise. But this appears to depend much upon the cross section shape of the plane.

I do not agree with Mr. Chatley's way of regarding the action of lifting screws. They should not be considered as fanning so much air in a downward or horizontal direction, but as screws, screwing their way through the air. There will be slip certainly, but if regarded as fans then the mind begins to picture the lifting effect as disappearing as soon as the screw moves in the direction of its axis. In fact, one flying machine inventor, to my knowledge, argues that a lifting screw is useless as the effort disappears as soon as the machine commences to lift; I do not agree with him. Mr. Chatley's explanations with reference to the shape of the blades of air propellers are not quite correct, as far as I am aware; his example of the Blackman and another fan having box pattern blades to prevent the air from being thrown off in a centrifugal direction, seems to show that he is under a misapprehension as to the action of air propellers. There is no necessity to shape the blades in this way; in fact, it may be a

disadvantage. I believe it is. W. G. Walker's experiments with air propellers show that contrary to the air being thrown away centrifugally it actually feeds to the fan blades at the circumference at an angle of about 45 degrees; my own observations have also confirmed this. The air leaves the propeller in a cylindrical flow, being at much greater density at the outer than the inner parts of the cylindrical area. I think Mr. Chatley has done well to refer to Mr. Walker's work, but a very important part of it was carried out with very large propellers to determine their lifting power. They were 30 feet in diameter, and show incidentally the value of the superposed or tandem blades referred to by Mr. Chatley. Narrow blades seem to be as efficient as wide blades. The results of these experiments were published in "Engineering" of 16th February, 1900. The author states: "Failure in screws means catastrophe." Is this really so? Will it not be possible to design the screws so that they will produce a parachute effect when stopped? I really think this is quite feasible, and that screws have been too hastily condemned in this respect. The trials of model flying machines at the Alexandra Park last year demonstrated the success of screws working in air. The accompanying photograph (from "The Model Engineer," Vol. XVI., by kind permission of the Editor, Mr.

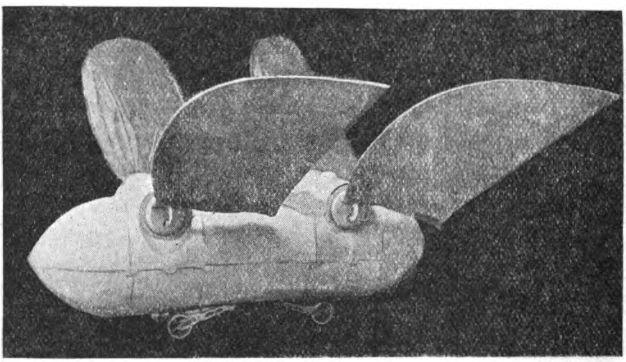


The Howard Aeroplane Model.

Percival Marshall) of Mr. Howard's aeroplane model, which gained second prize and made the greatest length of flight on the day of the trials, illustrates an example of this. The propeller and driving mechanism (clockwork) are of very small dimensions compared to the size of the plane. The illustration does not very clearly show them, but they are on the front vertical strut at the side of the identifying number 59.

Regarding the design of screws, the experiments of Lawrence Hargrave† show that he found that thrust diagrams should be regarded with caution. A high degree of thrust did not necessarily give the best results. A low thrust screw having blades at 45 degrees gave 50 per cent. increase of flight over a high thrust screw having blades of 20 degrees angle.

In regard to the question of danger to balloons by reason of projectiles, unless the projectile pierces the upper part of the balloon the damage does not seem to be of much consequence. The author's observations as to relation of weight to supporting surface are of much importance. De Lucy's conclusions‡ show that the heavier the winged animal the less supporting surface it has in proportion to weight. The sparrow weighs 339 times (according to De Lucy) less than the Australian crane, and has seven times more surface relatively to weight supported. Experiments have shown that weight is essential to flight, and the solution of the problems involved lies very much in the study of this part of the question.



The Bastin Aviplane Model.

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† Proceedings of the Royal Society of New South Wales, Vols. XVII. to XXIV.
‡ "Engineering," Vol. V.

With regard to the remarks on the aviplane .or flapping machine, an interesting model§ has been invented by Mr. Hugh Bastin, of Clapham, London. It weighs about 40 lbs., is 44 inches in length by 12 inches in diameter, the wings spread 84 inches from tip to tip, and are driven by a petrol motor contained in the body. The mechanism (at present a secret) produces a complete cycle of wing movement, which Mr. Chatley mentions as necessary to success. This model actually rises from the ground and flies forward without external assistance.

Mr. Chatley is deserving of admiration in being courageous enough, I may also say able enough, to come forward and present a paper upon this advanced subject on such a momentous and memorable an occasion. I consider that his treatise forms an excellent epitome of the salient points of the subject, and that it will be of much value as a part of our Transactions. Though, as Major Baden-Powell demonstrated in so interesting a manner, there is much to upset preconceived notions in the action of aeroplanes when launched in flight, yet Mr. Chatley's work is full of suggestive information for which he deserves our hearty thanks and encouragement. I trust, however, that he really does not wish us to regard the military aspect of the question as being the most important. In my opinion this should be the last consideration. Let us rather aim at the development of aerial navigation mainly for commercial, scientific and pleasure purposes, as we do with other branches of engineering work.

MR. W. GREEN, late Lieutenant, Tyne Division, Submarine Miners, Volunteers (R.E.), has sent the following note :—

My proposed mode of aerial locomotion is to fly laterally against the upward motion of a balloon instead of against the downward (gravitation) one of a bird.—*Vide* "The reign of Law," by the (late) Duke of Argyle, 1870. Amongst the features of the plan are :—The utilisation of the upward tendency of a balloon towards its motion in another direction ; the avoidance of the danger of being capsized as in a plain flying machine which depends on gravitation as its fulcrum. (Lilienthal, 1896 ; Pilcher, 1899) ; the avoidance of the obligation of the flying

§ The accompanying photograph of the model is taken from "Flying Machines," by A. W. Marshall and Henry Greenly, with the kind permission of Messrs. Percival Marshall and Co.

effort being unceasingly maintained; and descent to any lesser altitude, or to earth, to be effected by lateral or downbeats, without discharging gas, and a re-ascent without the discharging of ballast.

Author's Reply.

MR. HERBERT CHATLEY in replying, said how deeply he felt the honour of having read a paper on that occasion. It was, he believed, almost the first time that an engineering society had received a communication on the subject, and the meeting should, having regard to the number of great authorities present, form an epoch in the history of aerial navigation. With reference to Dr. Hele-Shaw's criticism of the slide showing the position of the stream lines, the parting of the stream lines should have been shown higher up the plane. He (Mr. Chatley) had stated, however, in the paper, that the centre of pressure was in front of the centre of gravity.

The Hon. C. S. Rolls had said that nature had afforded no colossal examples of flying phenomena. Naturalists, however, recorded the existence of the pterodactyls, the wings of which when spread, measured upwards of 30 feet across.

Referring to Mr. Lanchester's observations as to the word "aëroplane," in practice the "aërocurves" differed but very little from planes, and their action as curves was so little understood that for a simple exposition of the subject the first word would appear to be preferable. In regard to the word "helix," the word "propeller" was not used much in relation to ventilating fans, and the word "helix," like the French "hèlice," suggested all forms of screw. He considered that Mr. Lanchester went rather far in denying Langley's paradox. Its limitations had been mentioned in the paper, and it was almost certainly true within them. With reference to the soaring horizontal plane, the conclusions of Langley's plane dropper experiments bore on this question. As to the variation of angle from 20 degrees to zero, this meant that the angle should be variable at will between these limits, so as to vary the velocity from a minimum to a maximum. Mr. Lanchester contested the statement in the paper that the position of the centre of pressure affected the balance, although he himself referred to a "ballasted" plane. Professor Langley's

experiments with the equipoised eccentric plane, and the remarks which Major Baden-Powell and Dr. Hele-Shaw had just made, alone showed that upon the relation between the centre of pressure and the centre of gravity balance would largely depend. The work of Joëssel, Hagen, Kummer and others might also be referred to on this question. With regard to the tractor screw the fact had been mentioned in the paper that the air leaving was less efficient for lifting purposes. He was obliged to Mr. Lanchester for rectifying the omission of Dr. Levavasseur's name in connection with the Antoinette motor.

Replying to Mr. Parsons, he would say that the Sin^2 law was still referred to in many books and used in hydraulics, so that its inaccuracy should be noted. Professor Langley gave 0·00166 as his final average for the pressure constant. The action of air on curved surfaces was not yet well understood, and information as to the exact relation between the curvature, pressure, and position of the centre of pressure had not yet been published.

Respecting Mr. Marshall's remarks, the use of curved planes was not universally accepted, the results, although in some cases good, being somewhat uncertain. The Wright Brothers were understood to have discarded curved surfaces in favour of plane ones. Respecting the rigidity of the lifting surfaces, unless a system like that of Mr. Phillips were employed it would seem very difficult to ensure rigidity within the weight limit. Respecting the centrifugal flow in a fan, its existence in water had been proved by experiment. As to the action of lifting screws, unless the lifting speed were considerable, the dip would be almost equal to the propeller speed.

Replying to the observations at Birmingham in regard to turbines or electric motors for motive power, these were at present too heavy. Only about 75 H.P. per ton was necessary, but this question depended on the arrangement of the machine.

ANNIVERSARY DINNER.

The Twenty-fourth Anniversary Dinner of the Institution was held at the Hotel Cecil, London, on Saturday, 8th February, 1908, when 125 members and guests were present.

The chair was occupied by the President, M. Gustave Canet, who was supported by the following Officers and Members of Council, viz.: Messrs. F. R. Durham (Chairman), Geo. T. Bullock (Vice-Chairman), W. J. Tennant, Percival Marshall, Samuel Cutler, Jun., Kenneth Gray and Lewis H. Rugg (Past-Chairmen), Geo. H. Hughes (Member of Council representing Eastern Counties), F. D. Napier, J. Wylie Nisbet, R. H. Parsons and Chas. W. Pettit (Members of Council) and W. T. Dunn (Secretary and Treasurer).

Amongst the guests who accepted the Institution's invitation, although several were at the last unfortunately prevented, owing to various circumstances, from being present, were:—M. Leon Geoffray, Minister Plenipotentiary, Lieut.-Col. Huguet, Military Attachè, Commandant Schilling, Naval Attachè, of the French Embassy; Count de la Vaulx, Vice-President of the Aero Club de France, M. Julliot, designer of the airship "La Patrie," Capt. Ferber, of the French Military School of Aeronautics, Paris; Lord Justice Fletcher Moulton (Past-President); Mr. H. F. Donaldson, M.Inst.C.E. (Chief Superintendent of Ordnance Factories); Dr. Francis Elgar, F.R.S. (Vice-President of the Institution of Naval Architects; Mr. William B. Bryan, M.Inst.C.E. (Chief Engineer to the Metropolitan Water Board, Immediate Past-President); Lieut.-Col. R. E. Crompton, M.Inst.C.E. (President of the Institution of Electrical Engineers), and Mr. T. E. Gatehouse, M.I.Mech.E. (Hon. Member).

The President, in proposing the toast of "His Majesty the King," said that during those years when misunderstandings and distrust marked the relationship between the French and English people, the personality of King Edward always commanded the respect and admiration of Frenchmen. His knowledge of France and the affection with which he was regarded there, contributed more than any other circumstance to bring about that cordial understanding between the two nations which now happily existed. His every word and deed advanced the cause of peace by strengthening friendships and allaying suspicion. He pro-

posed long life and prosperity to that wisest of statesmen, most gracious of gentlemen, most democratic of rulers, and most Royal of monarchs, His Majesty King Edward the Seventh.

The toast having been enthusiastically received, and after the singing of a verse of the National Anthem, the other loyal toast was cordially acclaimed. The President in proposing it said: We shall, I am sure, now wish to express sincere respect and affection for Queen Alexandra, the Prince and Princess of Wales, and the other Members of the Royal Family. Gentlemen, you will, I know, join me in honouring this toast: "Long life and happiness to Queen Alexandra, the Prince and Princess of Wales, and the other Members of the Royal Family."

MR. F. R. DURHAM, as Chairman of the Institution, then proposed "The President of the French Republic." He said:—The President of our Institution has given us the health of our Sovereign in a most warm and complimentary manner, and I have now the honour of asking you to reciprocate by drinking the health of the President of the French Republic, Monsieur Armand Fallières. Such loyal toasts as these, proposed in association, carry with them not only our respectful homage to the heads of the respective States, but they have an international and political importance. For are not they the result of the co-operation of two great nations in the advancement of civilisation and of their sincerest wish to maintain the peace of the world? Therefore, I would ask you to drink this toast with deepest respect for our friends across the Channel, whose bond of union with us has set the world an example of the value of international friendship.

The toast was drunk with great enthusiasm, and a verse of Rouget de Lisle's soul-stirring hymn, "The Marsellaise," was sung in French.

LORD JUSTICE FLETCHER MOULTON, in proposing "International Science," said that science was a thing which united all nations as if they formed a common brotherhood. It was not because its votaries were men of the same race, nation, or family, but because they were comrades, and *camaraderie* was a bond as keen as brotherhood. Men of science were comrades. That *camaraderie* furthermore tended towards International Amity and Peace. In the work of science the nations were all competing together, but anxious really that knowledge should advance, whoever it might be that carried the torch forward. Theoretical

science, perhaps rightly, could claim that it unfolded the secrets of the magician—Nature. But practical science went further—it mastered them and used them. One of the most delightful moments in his career as an advocate was when he stood before the highest tribunal in the land to plead the cause of that great organisation, the Institution of Civil Engineers, who claimed recognition as a scientific society. He remembered that his text before that tribunal was the admirable definition due to Mr. Thomas Telford, and to be found in the Charter of that Institution, whereby he defines its objects as "the art of directing the Great Sources of Power in Nature for the use and convenience of man."

In locomotion, he said, nation had rivalled nation in invention. Respecting things which moved under the water, Frenchmen had set the world a long lead, and we had all that we could do to follow. As to locomotion on the sea, our ships had done, and were still doing, very respectable things, and regarding locomotion by land we had a very good record. We started railways, and the world had to learn about them from us, but we must own that it was the French who taught the world how to make a decent automobile. As to locomotion in the air, although we might not have got ahead of the French yet, well—he thought he would change the subject. (Laughter.) He grudged no nation its momentary triumph in scientific pursuits. Men of science were all-the-world-over comrades, fighting the common enemy of ignorance.

CAPTAIN FERBER in replying said: I have been asked to respond with Col. Crompton to the toast of "International Science." I have been so honoured because I come from abroad, but I do not converse in English, so that I must beg Col. Crompton to pardon me if I do not do justice in replying with him to the toast.

It is happily true that there exists international science. It is because of this that I can read this response. The learned international etymologists have taken most of the English and French words having the same origin. Therefore, this helps me, and as to the pronunciation, your Secretary, Mr. Dunn, has given me a lesson before dinner.

And why do the words have the same origin? We have two languages. Historic international science answers this question. All the languages—English, French, Spanish, Portuguese,

Italian, and others—have the same origin, because the Roman Empire conquered Europe, so that Latin has been the language of the leaders, who have influenced people. Thus, when I read these English words, I understand them, because they have the same origin as the French words. It is because the spirit of a Roman pro-consul is contained in them.

This is not all. We are assembled at this enjoyable banquet, and when I read the menu of names in French, I see that you are disciples also of our culinary philosopher, Brillat Savarin. In this hall you are agreeably warmed by perfect apparatus, for which manufacturers deserve great credit, but if physicists such as Dulong, Tyndall and Regnault had not by their investigations given the laws of heating, we could not have had them.

On the card of invitation for the dinner, I read that the time is to be seven o'clock. Why can we arrive so precisely. You may smile, because you have your watches, but where did you put your watch right? At the railway station probably; and the railway station clock, how was that regulated? The exact time was signalled from the Observatory at Greenwich, from the Observatory at Paris, and in Russia from the Pultawa Observatory. The astronomers of the whole world regulate their timepieces from the stars and the sun, after making calculations, and if such men as Kepler, Newton, Laplace, d'Alembert, Herschel and Foucault had not lived, we could not have worked to a second of time, as we have to do in the many affairs of our various callings. And as to steam, could we have benefited from it if Papin, Savery, Newcomen, James Watt, Fulton, Stephenson and others had not lived? And lastly, we could not have had artificial light, and power would not have been available for us, and our thoughts could not have been transmitted if Volta, Franklin, Faraday, Coulounb, Ampere, Ohm, Oersted, Herz, Marconi, Lord Kelvin, had not laid down the laws of electricity.

So in all we do every day we experience the many conveniences brought by the industry of science. But in the origin of all branches of industry we shall find a laboratory, where workers and savants made for progress in international science.

I drink to the health of the savants the wide world over, who to-day work unknown for the amelioration of humanity, from which our sons will profit.

COL. CROMPTON in his speech referred to the loss which science

had sustained by the death of Lord Kelvin, and announced that that famous scientist would be succeeded in the office of President of the International Electro-Technical Commission by the great French savant, M. Mascard. It would be his duty shortly, as Hon. Secretary, to go to Paris to formally inform M. Mascard of the fact. He considered that international science would benefit enormously by the work of this Commission; nations were separated chiefly by trifling customs, but scientific customs were identical the world over, and scientists, therefore, were essentially comrades. Col. Crompton also made allusion to the classic words of Telford in defining the objects of the Institution of Civil Engineers which had been quoted by Lord Moulton in the impressive address which he had just delivered to them.

MR. H. F. DONALDSON proposed, in congratulatory terms, the toast of "The Junior Institution of Engineers." Its vitality was shown by the fact that its membership now reached about 1,000. He had read with considerable interest the account of the origin and progress of the Institution, which had been presented at the "Coming of Age" celebration in 1905; and wished it continued success and prosperity in every direction. He noticed that the Institution was cultivating friendly relations with the Architectural Association, and he hoped that the result would be to exercise some control over the erection of the enormously high buildings which were known in America as "sky scrapers." He also referred to the President's world-wide reputation as an artillerist, and heartily congratulated the Institution on having such a distinguished engineer at its head.

MR. DURHAM, in responding to the toast of the Institution, said:—Mr. President, my Lord, Gentlemen,—In rising to reply to the toast of the "Junior Institution of Engineers," so appreciatively proposed by Mr. Donaldson, may I be permitted to review in a few words the developments which have taken place in our Institution during the last year. Although, sad to say, some of the founders and early members can no longer be accurately termed "Juniors," nevertheless those grown hoary and wrinkled in the service of the Institution never lose sight of the primary object of its foundation, which is to further the interests of the junior members of the profession. In order to encourage such members as have not reached the age of twenty-one, the Council have instituted a medal for the best paper

written by one of them ; thereby endeavouring to stimulate the ambition of the youngest members for study and for the formulation of the practical knowledge they acquire during their first years of professional training.

The relations of our Institution with the Senior Institutions and members of the profession, continue, to use a diplomatic phrase, to be friendly. We are receiving that support which we covet and honour. Our monthly transactions are now in their third year. We find that by this means we are keeping in much closer touch with our members in the country and abroad. The country members in Coventry and Birmingham are now regularly meeting in the respective cities, reading the papers as presented to the Institution, discussing them, and forwarding their remarks to London for insertion in *The Journal.* The Institution is encouraging and meeting the wishes of these members by drafting rules and bye-laws for the formation of local sections. We hope by this means to widen our sphere of international influence and to unite more firmly the large numbers of young and striving members of our profession.

The Institution, as a body, while conservative to the objects for which it was founded, is progressive. Owing to its increase of membership and prosperity, we have now considered it fitting to acquire a better meeting place than the Westminster Palace Hotel, and we have been fortunate in securing the use of the lecture room of the Royal United Service Institution ; this permission is another proof of the kindly feelings of a Senior Institution towards us Juniors. But this is not the only progressive action which the Institution has taken during the present Session. We have gone yet a step farther, with a boldness worthy of our youthful aspirations, for we have started a building fund, to collect in course of time a sum sufficient for the erection of a home of our own, either for ourselves alone or in co-operation with a kindred body.

What further proof of the progressive policy is needed, when we can boast of such a personality as M. Canet as our President. M. Canet himself the most progressive of men ! He has shown his sympathy with our ambitions by laying the foundation stone of that very building fund by his munificent donation of £100. We are well rewarded for our fearlessness in going abroad to ask the most distinguished engineers to become our Presidents, and

the reception of our offer and its acceptance by M. Canet once more proves the sympathy which we have the good fortune to attract wherever we turn.

I feel it would be wrong not to refer to the epoch making meeting of last night, when the interesting paper on "Aerial Navigation" was read, and we had such distinguished men in our midst as Monsieur Julliot, Capt. Ferber and the Comte de la Vaulx. This year's Summer Meeting of the Institution will take the form of a visit to the engineering works at Paris, Creusot and Havre, where the interest of the Juniors is certain to be again displayed by the number of Members who will avail themselves of this exceptional opportunity.

I need scarcely say any more, as I feel sure this indication of a few facts will convince all those present of the efforts and the progress of the Institution, and of its aim to maintain the noble objects for which it was founded.

The health of "Our Guests" was proposed in felicitous terms by Mr. Samuel Cutler, Junr., who, in the course of his remarks made special reference to the French gentlemen present, and to Lord Justice Fletcher Moulton and Mr. W. B. Bryan, two of the Institution's Past Presidents, the list of whose names indicated the intention of including distinguished representatives of every branch of engineering science as occupants of the presidential chair.

The toast having been honoured with great warmth,

THE PRESIDENT rose and said:—In recognition of the work which Count de la Vaulx, Capt. Ferber and M. Julliot have done for the progress of aeronautics, the Council desire to confer on them the Honorary Membership of the Institution. They wish me once again to thank these gentlemen very cordially for having assisted at the meeting last night, which, as has already been said, will be regarded as an epoch-making incident in the history of aerial navigation.

M. Julliot, Capt. Ferber and Count de la Vaulx were then invested with the Badge and were presented with the Certificate of Honorary Membership of the Institution.

The COUNT DE LA VAULX responded on behalf of the guests, expressed appreciation of the welcome which they had received, and assured the members that theirs would be equally cordial when they visited France. In the absence of Dr. Francis Elgar

owing to indisposition, Mr. Deputy Wallace, member of the Corporation of the City of London, also replied in an exceedingly well-delivered speech.

The toast of "The President" was then submitted by Mr. W. B. Bryan, who remarked that a more ideal President could not have been selected, inasmuch as M. Canet had held the post of President of the Institution of Civil Engineers of France.

After the toast had been most cordially honoured,

The PRESIDENT said:—The task of responding to the toast of his own health is one which no person, however brave, or however much he may be in sympathy with the proposition, can undertake without trepidation. It is, perhaps, the only toast, in replying to which one would be justified in leaving out of consideration the subject on which he is supposed to be speaking. It would, however, be discourteous to refrain from expressing to the best of my power my thanks to the speakers who have so flatteringly estimated my virtues, and to you, gentlemen, for having so warmly received their words. Not even an elderly gentleman who has just enjoyed a good dinner could remain in his seat unmoved by the heartiness with which his health has been drunk, and I thank you one and all most sincerely.

The honour which you have conferred upon me by electing me to the Presidency of your Institution is one which is, I think, unique of its kind. That a Society should go beyond the borders of its own country to choose a recipient for the highest honour it has to bestow is an event which may be looked upon in two ways, both as being a very great compliment to the individual and as proving how truly international is the realm of science. I prefer, however, to find yet another explanation of it, and to regard it as a token of the cordial understanding which binds together the nations of England and France.

That such a step should have been taken by a Society representing, as yours does, the junior members of the profession, seems to me to have great significance. Friendships are formed more readily in youth than afterwards, and they are more lasting. My regard for England and the English dates from the days when, quite a young man, I first came really to know this country, and it has endured ever since, unchanged even during the period when Frenchmen and Englishmen spent most of their spare time in reviling one another. The *Entente Cordiale* would have been

brought about years before if I could have had my way, as a little story I will tell you will show.

Once upon a time, many years ago, when I had my home in Wandsworth, a Parliamentary election took place. Of course I did not imagine it could concern me in any way, until one day a man called on me to solicit my vote for one of the candidates. As soon as ever he saw me he began, "My dear sir, I need not ask your politics, for I am sure that like all reasonable men you belong to our party. Do not let your confidence in the certainty of Mr. So and So's election prevent you from doing your duty to your country and recording your vote in his favour. You need not trouble to walk to the poll to-morrow, as a carriage shall call for you. 'Good morning, sir, good morning,'" And with that he rushed away, leaving me wondering what I had let myself in for.

While he had been talking I had had no chance of getting in a word edgeways, to tell him I cared nothing of politics and did not know even the names of the candidates, and that even if I did, I was a Frenchman and not an Englishman. Had he let me speak, no doubt he would have found out this for himself, but he took things so much for granted that I could say nothing. I suppose my name must have somehow go on the register because I lived a respectable life and paid my taxes like an Englishman.

Well, the next morning a carriage gaily bedecked with party colours drove up to my door to take me to the poll. I hesitated somewhat to enter it, because I thought I should be eternally compromised in the eyes of my friends, but I decided to see the fun through, and was soon on my way to the poll. Now, the night before I had made enquiries as to the views of the two candidates, and had found that one seemed less averse to a friendly understanding with France than the other, so when we arrived I marched boldly in and marked my ballot paper opposite his name. Thus I gave expression to my views on Anglo-French relationship, in spite of the fact that it had necessitated voting for the opponent of the candidate whose vehicle had so kindly taken me to the poll.

I trust that all the members of the Junior Institution will learn to know and like the French as I have learned to know and like the English. To really understand a nation, it is not enough to read about it, one ought to go and see the people in their own

country. You will have an opportunity of doing this in a few months time, when you hold your Summer Meeting in France, and I trust as many as possible of you will avail yourselves of it. I shall have the pleasure of meeting you again on the other side of the Channel and shall do what I can to ensure the success of your visit. Besides the sights which every tourist sees, many interesting works will be open to your inspection, and I hope you will derive both pleasure and profit from your trip. I thank you again, gentlemen, for the cordiality of your reception of the toast of my health, and will only say in conclusion that I trust that the prosperity of the Institution will be no less marked during my year of office than in the years of my predecessors.

A deviation from the programme of the evening was made by the President proposing the health of "The Secretary of the Institution," which having been heartily drunk, Mr. Dunn in a few sincere words acknowledged.

The toasts were interspersed with musical selections excellently rendered, under the direction of Mr. Richard Cooper, A.R.C.O., in which Miss Gertrude Snow (soprano), Miss Carrie Herwin (contralto), Mr. Harry Child (tenor), Mr. T. E. Gatehouse (violin), and Mr. Edward Cherry (character sketches) took part.

ARCHITECTS AND ENGINEERS.

A Combined Meeting of the Discussion Section of the Architectural Association and the Junior Institution of Engineers was held at the rooms of the Architectural Association, 12 Tufton Street, Westminster, on Wednesday evening, 12th February, 1908, the attendance being 42.

The chair was taken at 7.30 p.m. by the Chairman of the Discussion Section, Mr. K. Gammell, who expressed, on behalf of its members, the pleasure they felt at seeing the members of the Institution once more amongst them.

A paper entitled "Suggestions as to how the Architect and Engineer can Combine" was read by Mr. Percy J. Waldram, F.S.I. (Past-Chairman of the Institution).

The discussion upon it was opened by Mr. W. Wonnacott, who also proposed a vote of thanks to the Author for his paper, which was seconded by Mr. Travers. The other speakers were Mr. F. R. Durham, Mr. J. H. Pearson, Mr. Hamp, Mr. Foster, Mr. R. Marshall and the Chairman.

To Members in the Colonies and Foreign Parts.

There are Members in the Colonies and Foreign parts who have not yet responded to the request for some account of their doings.

Communications from them, either in the form of letters or articles, will be cordially welcomed for insertion in *The Journal.*

"SUGGESTIONS AS TO HOW THE ARCHITECT AND THE ENGINEER CAN COMBINE."

By PERCY J. WALDRAM, F.S.I. (Past Chairman J.I.E.)

Read 12th February, 1908, at a Combined Meeting with the Discussion Section of the Architectural Association.

Upon receiving the honour of a joint invitation from the Discussion Section of the Architectural Association and the Junior Institution of Engineers to read the present paper, the author naturally recalled the first of those interesting and instructive joint meetings when two papers were read treating the subject generally from the point of view of the architect and of the engineer respectively.

The quotation of a few extracts from those two papers in order to compare the present position of that with about ten years ago, will be of advantage:—

"The English architect, as a rule, knows the engineer chiefly as a painful necessity, who requires obtrusive beams and tie rods which would not harmonise; the representative of strong and massive ugliness, who would get over difficulties if he were allowed to have his own way, but whose effect on a building is to be dreaded. The engineers' idea of an architect was often that of a man who wanted results, and whose client could afford to pay for them; who could not or did not invite competition, and with whom there was no great necessity to take much trouble not to make modest estimates. If the architect's buildings and his client's interests suffered from elementary engineering design, that was not the engineer's business; he had other things to trouble about besides the relations of economy many times removed."

. . . .

"Engineers should not hesitate to seek the collaboration of architects whenever architectural skill was necessary with their work. Architects have the responsible control of a very large field of engineering work and a still larger field of potential work now left untouched."

"It is the imperative duty of Institutions on both sides having a proportion of younger members to do all in their power to extend early and fruitful connections."

. . . .

These words were penned exactly ten years ago. Why is it that no material progress has been made since then? Why is it that Continental and American practice is to day miles ahead of British in the facility in which each profession absorbs all that is best in the other? Why is it that whilst British buildings will bear comparison architecturally with any in the world, they yet lack so many of the countless improvements effected by modern engineering improvements which abroad one sees adopted as a matter of course? Is it a small thing that whilst other nations are progressing in this matter by leaps and bounds, our architects and engineers are still groping in a fog of mutual distrust? The fact that we are lagging far behind where we ought to lead calls loudly for a remedy, and for a remedy far more virile than academic discussion, and the expression of pious opinions.

The author does not wish to suggest that the professions of architecture and engineering should be in any way amalgamated, as in America, but desires to show that each constantly needs practical assistance from the other, and that it is not impossible even under the present conditions of practice in England for each to obtain it.

A short consideration is first necessary as to what need exists in each profession for the work of the other.

The need of Architects for the work of the Engineer.—Architects of experience will readily admit that in many highly important, although somewhat subsidiary branches of their work, great progress has been and is being made by engineers, and that correspondingly great advantages are to be gained to modern buildings by utilising the high technical skill of the engineer. In connection with such matters as water supply, sanitation, heating, artificial lighting, ventilation, steelwork, reinforced-concrete construction, and the design of foundations, piers, retaining walls, &c., the engineer has at his disposal a wealth of data founded upon practical experience and research which the curriculum of architectural training of necessity cannot include, any more than it can include the scientific training which alone enables such data to be applied with advantage.

For instance, when the architect has to design a country house or a hospital beyond the reach of public sewers and water mains, what time has he to devise schemes of water supply and sewage disposal? If he has little time, he certainly has less inclination. He requires the aid of an engineer, and he readily admits it.

In connection with heating, lighting, and ventilation, he is fully aware that his knowledge and experience is limited to ordinary expedients, and when his buildings require steam heating, electric plant, and mechanical ventilation, he looks around for experts in those matters. As soon as his floors and roofs exceed moderate spans and the loads on his bressummers grow large, he wants the advice of a good steelwork designer, whilst to attempt, in the brief time which his clients allow him for his other important and complex duties, to design in reinforced concrete is simply a sheer impossibility. When he is called upon to deal with bad or heavily stressed foundations, or even with unusual loads on good ones, he acknowledges that he needs skilled advice ; and even over retaining and river walls he often has uneasy qualms as to whether much of the masses of expensive material demanded by his small text books might not have been safely dispensed with.

Yet, although all these are matters falling well within the scope of his everyday work, the conditions of modern practice in England make it extremely difficult for him to obtain skilled engineering assistance, or at least to obtain it in a way conducive to his client's interests and his own. Unfortunately, consulting engineers in England are generally only appealed to in the case of very large work. Their fees are, in consequence, usually extremely high, and they naturally feel a distaste for small work at correspondingly low fees. Their recommendations also do not as a rule err on the side of economy.

Suppose an architect goes to a client and, confessing his own ignorance, suggests that the advice of a consulting engineer be obtained at a fee equal to perhaps half his own fees for the whole work, what chance has he of getting it? Even supposing he is able to arrange that the water supply and sewage disposal work should be placed in an engineer's hands (incidentally losing it himself) what chance remains of getting say a steelwork designer and an electrical engineer as well on the same contract, however necessary they may be? Clients who will cheerfully

face an extra expenditure of hundreds of pounds on a contract in order to obtain some quite unimportant fad of their own will indignantly refuse to pay one-tenth of the amount in extra professional fees. There are few things more firmly fixed in the average British mind than the idea that the architect's fee of five per cent. includes everything.

Such considerations lead to the architect being forced to go to the manufacturing engineer, who is smart, up to date, ready at all times to advise and design for the architect, but naturally taking care to impress him with the extent of the obligation involved, and continually to remind him of it until the work is secured without competition at a price which the architect's knowledge does not permit him to criticise.

What is the consequence? The manufacturing engineer having *carte blanche* both as to design and price—unreasonably large sums are often quoted for engineering work. If the estimates are accepted, essential parts of the building elsewhere have to be starved; decoration, for instance, is a most important essential to the value of a building.

If the engineering work is cut out in favour of some cheaper and less efficient expedient, the client is dissatisfied as soon as he finds that he has not had the advantages he might have had—the reason of which he attributes to his architect's ignorance.

The engineering contractor, if his estimate be accepted, feels that he has in a sense bought his job with his advice and designs, and the independent position which this gives him makes him averse to subordinating his design and methods to the superior requirements of the building. He grows accustomed to giving the architect whatever he has been accustomed to use to obtain the object in view, without any regard to æsthetic and other—to him—minor considerations. Thus arrives the unfortunate condition of affairs that even an experienced and broad-minded architect, whilst appreciating to the full the constant triumphs of the engineer, prefers to have as little as possible to do with him in his work. In this he is unduly prejudiced, but he has a considerable amount of reason on his side.

What architects really need is the work of engineers who, whilst skilful, experienced and well abreast of the times, are neither biassed nor in a position tending to influence their work and their judgment in the commercial interests of their own

pockets. Architects want men who are ready to undertake small work at correspondingly small fees, and who will be willing to frame and vary their designs to comply with the requirements of their buildings. There is plenty of work for such men if the architect only knew where readily to find them, and the need of their services is increasing every day.

The need of Engineers for the work of Architects.—Engineers will no doubt think that the foregoing remarks as to the architects' need for their services are merely self-evident platitudes. They may find food for discussion, and possibly for subsequent reflection in the suggestion that they have not unfrequently quite as much need for the work of the architect. Unfortunately the average engineer, especially the average manufacturing engineer, seldom appreciates the work of the architect to the same extent that the architect appreciates his. As one who in his daily business constantly attacks novel and difficult problems, he is apt to consider that the architect practices an easy old-fashioned art somewhat hide-bound in old traditions and customs, and not very practical in its methods; a calling which makes none of those demands on initiative, courage, and skill which engineering work does. In fact, that the architect is useful in his way, but the last man in the world that an engineer would go to for practical assistance.

This view is very wrong, and quite unjust to any architect worthy of the name, but one can hardly say that it is quite without justification as regard some architects in practice. Unfortunately, it tempts the engineer to the conclusion that any practical man who knows what he wants can, with the aid of a text-book, easily design, specify, and superintend, any building work which does not require so-called ornamental treatment; such as workshops, stores, engine-rooms, retort-houses, power-stations, and the like. This is almost invariably a most expensive mistake. Wood, stone, bricks, lime, and cement, may seem easy enough materials to work in, to one accustomed to intractable metals, but every practical builder knows that the specifying of the proper materials to be used, even in the simplest building work, demands considerable knowledge; a want of which—or even any ignorance of market sizes, forms and prices, may run up the cost of building very considerably, certainly to an extent equal to much more than an architect's fees; and that however

simple and straightforward a piece of building construction may appear to be, its design by unskilled hands almost invariably means higher cost and reduced efficiency.

The present system of competitive tendering on rigid contracts has also forced the builder to cut his contract prices to the lowest possible limit, and then to keep a sharp look out for extras. He very well knows how to turn to his own advantage the slightest omission or slip in drawing, specification or quantities, even to the extent of basing a legal claim for extras upon an error in punctuation.

The specifications and contracts of a skilled architect are legal documents compiled clause by clause with the utmost care, skill and forethought; his contract drawings are voluminous and precise, and his detail drawings are ample. All that trouble is not taken for amusement, but because harsh experience has shown it to be necessary, and the risks that are run in the compilation of contract documents and drawings by amateurs can be well imagined.

Even supposing that it were possible for the practical man to design and accurately and exhaustively specify work in the best ordinary methods of building, surely an up-to-date but discriminating knowledge of new materials and methods is at least desirable. The mere mention, too, of local bye-laws calls up a vista of countless pitfalls which architects have learned how to avoid when designing, but which even a High Court Judge has been known to fall into. Then take the question of superintendence, how many practical engineers are there who would not consider themselves capable of superintending ordinary building work quite as well as any architect, if not better? Yet building operations are a combination of several highly specialised trades, each with its own tricks and dodges to reduce cost even at the expense of efficiency; tricks as old as the hoary old architectural customs which were devised and are still retained to circumvent them. Surely it is better to entrust the superintendence of such work to a man who knows just where to look at once for evidences of scamped work, or rather of that particular scamping which is liable to affect the safety and durability of the structure. One is constantly coming across in practice cases where so-called "practical" drawings and specifications omit points apparently insignificant, but which are highly

important when it comes to making up the final accounts of materials specified which have a well deserved reputation, but which are either unsuitable or only obtainable at great expense; of timber specified in theoretical text-book dimensions instead of in imported sizes; of brickwork in which every brick has to be cut; and of those terse concise conditions of contract so dear to the practical mind, but which break the heart of the professional man called in to settle up the inevitable dispute over the accounts. When, in addition to this, the practical man prepares bills of quantities, matters become hopeless, and it is generally a case of being legally compelled to pay whatever the builder's conscience permits him to charge.

Two recent cases may be cited to show how money can be literally thrown away under so-called practical contracts. The first was that of a gas works engineer in extending his retort house. A firm of contractors tendering on quantities supplied by the engineer, finding that those quantities were to be taken on the contractor's responsibility, asked the author to check them. Upon comparing the quantities with the drawings and specification, an interview with the engineer was found necessary. It was pointed out to him that London stock bricks which had been specified (the work was simply a brick shell with foundations and a roof) would cost twice the price of hard Flettons, in addition to which the nearest brickfields were some seven miles distant by road, whereas the railway sidings which had direct communication with the Fletton brickfields at Peterborough ran right up to the end of the new building. Various other equally important considerations and necessary information had been overlooked. So great was the amount of brickwork taken that at first sight it appeared as if the retort house was to be built solid and the interior cut out as required. The amount of concrete given was quite in proportion, although the digging was by comparison small.

Upon asking the engineering draughtsman, who had been specially employed to save an architect's fee, how he arrived at his figures, his dimensions were produced, and it was found that the brickwork had been originally reduced to yards super. and so billed, but someone had altered the description to rods, a little mistake which it was nobody's business to detect. The excessive concrete was explained by the fact that it had been billed

in yards and feet so as to be *very* exact. Unfortunately for this conscientious accuracy the feet not being clearly so-called were added by the typist on to the end of the yards as one figure. These little errors were only discovered and pointed out the day before the tenders were due. The result was that the author was desired to send in his client's tender with a corrected drawing and a revised specification, which was done, and the tender (about £2,500) was successful, being nearly £300 below the next man who also tendered on revised quantities. The other tenders were never published, but one at least was £1,000 or more above the lowest. The work was carried out to everybody's satisfaction.

In another and similar case the works manager of a large electrical manufacturing firm drew up a specification and plans of two new erecting shops. On examining the brief particulars, the author was enabled to point out many very expensive and unnecessary items, such as fixed casements instead of direct glazing to the solid frames, and a classic (*sic*) entrance porch in stone, which, as the engineering draughtsman truly said, "gave a finish to the whole thing." On the other hand, a small fortune awaited any contractor sharp and hardy enough to charge for all the necessary items which had not been specified. In this case also fresh tenders were obtained on a proper basis.

The danger of proceeding in the above manner requires to be brought home to engineers, and the author would put it to them in strong terms of recommendation that a practical mechanical turn of mind is only one important qualification out of many which are essential in order to carry out building operations so as to get the best results for the money expended. He urges that money would be saved and better results obtained by putting even the simplest building operations in the hands of practical architects, irrespective of the chances of reciprocal business which might result from doing so.

The kind of architects whom engineers need are experienced, practical, up-to-date men possessed of a discriminating knowledge of materials and processes, ready to undertake small work, and who are, above all things, able to express their ideas of beauty (at least in utilitarian buildings) through the best adaption of means to an end, rather than by the application of extraneous ornamentation. The extent of building operations required in

connection, directly or indirectly, with modern engineering work is so large that there is plenty of work for such men if engineers only knew where readily to find them.

Present difficulties in the way of Collaboration.—The present difficulties on both sides in the way of collaboration may be summarised as follows:—(a) The difficulty of finding readily the right man at the right fee; (b) Professional prejudices; (c) Custom.

Professional prejudices on both sides assert that the first difficulty is insuperable; that all engineers are either commercial minded manufacturers, or expensive autocrats from Great George Street; that architects are fanciful artists, and that the young architects who would take small work are even more exuberant and impracticable in their ideas than are the older men. In short, that as the right men do not exist, why trouble to try to find them? Why not follow the customs which, with all their faults, were good enough for our fathers? A very easy, and unfortunately a very English way of looking at the matter, but none the better for that.

The present paper being primarily intended to promote discussion, these conflicting views—which provide the crux of the whole matter, may well be left to form the basis for discussion. The author's own view is that the right men do exist, and can be found by proper machinery, and that the supply of them would increase with increasing demand. But he would venture to suggest that a discussion of very little real value will result if both sides confine themselves to mutual recrimination—if the architects only point out that engineers cannot "design in beauty," and the engineers only retort that the architects cannot "build in truth." Even if each side cannot see the matter entirely from the other's point of view, they can at least both try to obtain the advantage of a stereoscopic view by looking at it with both eyes open.

Suggested aids to Collaboration.—If the right men do exist on either side, are they not more likely to be found amongst the members of the two professional Societies represented at this combined meeting than anywhere else?

The most hopeful machinery—in fact the only possible machinery for bringing architects and engineers into better and closer business relations must be brought into operation by the

respective Councils of these two junior Societies. Combined meetings will not do it, however helpful they may be in eliciting valuable opinions from both sides. Opinions never effected a reform and never will. Somebody has got to work with enthusiasm, perseverance, and disinterestedness, and the author suggests that the two Councils should recognise the pressing need for closer and better relationships, and do what ever lies in their power and close to their hands to effect a radical change.

Extension of the existing Appointment Registries.—Appointment registries exist in both Societies. These might well be extended to include not only assistants, but also men in a position to undertake responsible work in collaboration with members of the other Society, so that on the slightest call from the other side, the names of men, and what is far more important, the right men may at once be available.

Committees of Selection of Members for Nomination.—The secretarial staffs, with their extensive and personal knowledge of members, can do much, but they might with advantage be assisted by small committees sitting at frequent intervals and composed of men whose knowledge and experience is wide, and whose discretion can be relied upon.

Standing advertisements in the Journals.—In every copy of the Journals of both Societies, standing announcements should direct the attention of every member—in season and out of season—to the new order of things. The engineer and architect needs to find staring him in the face every time he opens his monthly Journal a reminder that the Secretary of the other Institution is ready to supply his needs whatever they may be. He might see such a reminder a dozen or a hundred times before he makes use of it, but when it has once occurred to him what time he is in a difficulty and has got from the Secretary the right man—he will need no more reminders. On the next occasion he will ring up and get his man before the difficulty comes. The value of all advertisements lies in the feeling of a want satisfied.

The task of selecting and registering the right men for recommendation would require tact, judgment, experience, and care, and a place on the proposed Selection Committees might well be accounted an honourable distinction.

This scheme is not a mere vision; the system is being carried on to-day by the Junior Institution of Engineers, and carried on

successfully. That Institution rejoices in a Secretary whose tact and experience is only equalled by his extensive personal knowledge of members. Engineers' work frequently involves a branch other than their own, and then they want to co-operate with men of greater skill or experience in that branch, just as the architect would. How to find the right man causes a member of the Junior Institution of Engineers no anxiety. "Victoria 912 please," is the formula he applies, and after a few minutes conversation with Mr. Dunn he is in possession of the names and addresses or telephone numbers of likely men, or else he has been promised that someone likely to know the right man shall be communicated with.

The Councils and Secretaries of the senior Institutions are constantly nominating men at the request of outsiders. Why should not the junior Institutions do the same for each other?

Suggestions as to how Engineering Assistance can be paid for otherwise than out of the Architect's Fees.—It appears to the author that the following may be a possible solution to the highly important question as to how engineering assistance can, when necessary, be paid for without encroaching on the architects' fees.

The cost of reinforced concrete, electric lighting, special ventilation, &c., is usually included in the contract in the shape of lump sums. Generally, but not always, the quantity surveyor draws his percentage on these upon which he does practically no work; but no quantity surveyor would dream of standing out for this to the extent of refusing work upon which he was to be paid only on the work he measures; and rightly or wrongly the custom is growing in public contracts of excluding such sums when calculating the surveyor's fees. The author's suggestion is that an architect should so reserve the quantity fees on such provisional sums for engineering work and devote them to paying for skilled specialist assistance in designing and specifying such work and obtaining competitive tenders from reliable engineering firms on identical particulars.

The funds available would certainly be small, but the author believes that they would be sufficient to form an adequate remuneration for the calculation and preparation of general designs, specification and quantities upon which to obtain competitive tenders. The engineering contractors tendering might

either add to their estimate the cost of detail and erecting drawings, to be approved by the consulting engineer or a sum to pay the latter for the preparation of such drawings might fairly and properly be added to the estimate.

The question of constructional steelwork is slightly different because it entails at times on the quantity surveyor the task of seeing that all unsupported walls, floors, &c., are duly provided for. This, however, can hardly be considered to be a very serious matter, and it is only necessary when the steelwork has been carelessly designed.

Something between 1½ per cent. and 2½ per cent. for general designs, specification and quantities of steelwork does not seem at first sight to be a princely remuneration, but it compares favourably with the scale of fees paid by large railways for the complete design of bridges and viaducts involving far more intricate calculations and detail drawings. Several years' experience of such railway work and of ordinary constructional steelwork enables the author to say that it certainly does leave a fair margin of profit.

Such a system leaves untouched the inelastic and well earned fees of the architect. If it could be adopted, the author suggests for the earnest consideration of his fellow members in both societies, that it would not merely benefit the architect, the engineer, and the client, but would tend to restore the art of building as practised in England to the place it ought to occupy in the architecture of the world.

[*On account of pressure on our space the Discussion on the Paper has to be held over till next month. Members are invited to send for insertion in "The Journal" then an expression of their opinion on the suggestions contained in the Paper.*—ED.]

Part 7. **APRIL, 1908.** **Vol. XVIII.**

The Junior Institution of Engineers
(Incorporated).

President - - GUSTAVE CANET, M.Inst.C.E.,
Past-President Institution of Civil Engineers of France.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

Telephone—
No. 912 Victoria.

39 Victoria Street,
Westminster, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

2nd April, 1908.

ANNOUNCEMENTS.

TUESDAY EVENING, 7th April. Meeting at 8 p.m., at the Royal United Service Institution, Whitehall, when a Paper on "**The Purification of Water,**" by Mr. George H. Hughes, M.I.Mech.E. (*Member of Council for Eastern Counties*), will be read and discussed.

SATURDAY AFTERNOON, 11th April, at 3 p.m. Visit: The Purley Works of the East Surrey Water Co., close to Purley Station of the L.B. and S.C. Ry., by permission and under the guidance of the Engineer, Mr. A. E. Cornwall Walker. Train leaves London Bridge at 2.10 p.m. *Special railway tickets, 1s. 5d. return, can be obtained from the Secretary of the Institution upon application before Friday, 10th April.*

TUESDAY EVENING, 12th May. Meeting at 8 p.m. at the Royal United Service Institution, Whitehall, when a Paper, entitled "**The Design of a Sewer,**" by Mr. Frank R. Durham, Assoc.M.Inst.C.E. (*Chairman of the Institution*), will be read and discussed.

SUMMER MEETING IN FRANCE. The party leave London on Saturday, 27th June, returning Saturday, July 11th. The Outline Programme was issued with the March Journal. Arrangements will be made for members, who may so desire, to take one week only.

INSTITUTION ROOMS. The Rooms of the Institution are kept open **every Friday evening** during the months of October to May, inclusive, for purposes of social intercourse.

LECTURES ON SUCTION GAS PLANT. A special course of Three Lectures will be given at the East London College (University of London), on 27th May, 3rd June, and 10th June, 1908, at 8 p.m., by Assistant Professor C. A. SMITH, B.Sc. (*Member*). The subject matter will include:—Description of typical plants; methods of working; fuel used; applications; commercial figures concerning capital cost, depreciation and cost of working. The lectures will be fully illustrated, and have been arranged for engineers in practical work. Members of the Institution have been invited to attend free of charge. Tickets may be obtained on application to the Registrar of the East London College, Mile End Road, E.

The Council have the honour of announcing the following elections:—

Vice-Presidents.

SIR WILLIAM HUGGINS, K.C.B., O.M., D.C.L., LL.D., Past P.R.S. (in succession to the late Lord Kelvin), 90 Upper Tulse Hill, S.W.

SIR ARCHIBALD GEIKIE, K.C.B., F.R.S., Shepherds Down, Haslemere, Surrey.

PROFESSOR J. J. THOMSON, F.R.S., Cavendish Professor of Experimental Physics in the University of Cambridge, Holmleigh, West Road, Cambridge.

Honorary Member.

PROFESSOR JOHN T. NICOLSON, D.Sc., M.Inst.C.E., Professor of Engineering, The Municipal School of Technology, Manchester.

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

AIJAR, T. S., KODANDARAWA; Mayavaram, Tanjore District, Southern India.

BALLANTYNE, WILLIAM MYLES HOWARD; Messrs. Everett, Edgcumbe and Co., Hendon, N.W.

CONN, WILLIAM JOHN; British North Borneo State Railway, Beaufort.

COWAN, ANDREW WALLACE; Messrs. Redpath, Brown and Co., Riverside Works, East Greenwich, S.E.

CRABBE, FREDERICK JOHN; H.M. Dockyard, Sheerness.

ELLIS, LEONARD ROTHERY; Messrs. J. H. Tucker and Co., King's Road, Birmingham.

HAY, JOHN; Messrs. Mumford and Co., Colchester.

VICKERS, ALLEN ; Battersea Borough Council, Town Hall, Battersea.

WILLIAMSON, HARRY; Oficina de Via y Obras, Ferro Carril de Buenos Aires at Pacifico Bahia Blanca, Argentine.

Proposed for election to the class of "Associate."

OSBURN, RIMINGTON ; Admiralty, Controller's Department, Whitehall, S.W.

RAMASWAMIENGAR, M. S. ; East Khandesh District, Bombay Presidency, India.

SELDON, EDWARD ; 224 Croxted Road, Herne Hill, S.E.

Changes of Address.

CHABOT, V. H., Engineer's Office, South Indian Railway, Trichinopoly, India.

COLSON, J. K., 33 Lansdowne Road, Holland Park, W.

COLE, C. ERIC, Woodland Cottage, Chelsfield, Kent.

DYER, A. J., 38 Canton Street, Poplar, E.

DICKSON, A. J., 10 Vincent Street, St. Helens, Lancs.

EVETTS, G., 124 Wood Vale, Forest Hill, S.E.

GOODMAN, R. C., 69 Fairlop Road, Leytonstone, E.

GOFFE, EDWARD, New Club, Johannesburg, Transvaal, S.A.

GOULBORN, VERNON, c/o Mrs. Hill, 66 Alexandra Road, Patricroft, Manchester.

GRAY, KENNETH, 28 Badminton Road, Nightingale Lane, Clapham Common, S.W.

JONES, A. R., 160 Broomwood Road, West Side, Clapham Common, S.W.

MAIDEN, EARL, 16 Yukon Road, Balham, S.W.

MATTHEWS, M. H., 53 Douglas Street, Derby.

PILLING, F. S., 23 Bristol Road, Edgbaston, Birmingham.

SYDENHAM, J. W., c/o Messrs. Bruce, Peebles and Co., Ltd., Edinburgh.

WALMSLEY, R., Calder Vale, Scarisbrick Road, Southport.

PERSONAL NOTES.

R. P. ADAMS has accepted an appointment with the Bengal Government as Temporary Inspector of Factories. Address, 22 Writers Buildings, Calcutta.

PERCY BALL has entered the service of Messrs. Woodnut and Co., St. Helens, I. of W. Private address, 2 Rosebery Villas, Latimer Road, St. Helens, I. of W.

GEORGE CANNING has sailed for Sekondi, Gold Coast, on business for the Clayton Fire Extinguishing Co.

G. F. DEWYNTER has been elected an Associate Member of the Institution of Electrical Engineers.

GEORGE EVETTS has passed the examination of the Institution of Civil Engineers for Associate Membership.

ARTHUR FINBOW has returned from the United States after sixteen months absence and is about to enter the works of Messrs. Aldridge and Rankin, makers of the Fiddes-Aldridge gas retorts simultaneous discharger-charger.

Dr. H. S. HELE-SHAW (*Hon. Member*) has been elected a Vice-President of the Incorporated Institution of Automobile Engineers.

STANLEY M. HILLS has been admitted a student of the Institution of Electrical Engineers.

P. T. HINE is now in the Drawing Office of The Electric Construction Co., Wolverhampton. Private address, "Fernleigh," 175 Staveley Road, Wolverhampton.

J. W. LLOYD-JONES has obtained an appointment with Messrs. Ruston, Proctor and Co., of Lincoln.

H. J. NOWLAN has been appointed Assistant Draughtsman on the staff of Messrs. A. D. Dawnay and Sons, Steelworks Road, York Road, Battersea.

CHAS. W. PETTIT is engaged on the construction of the New Filter Beds and Reservoir at Long Ditton, for the Metropolitan Water Board, as Agent and Engineer to Messrs. J. Moran and Sons. [*742 P.O. Kingston.*]

G. W. POTT has obtained an appointment with Messrs. Drake and Gorham, 66 Victoria Street, S.W.

H. C. RICKWOOD has left London owing to the Power Gas Corporation staff having been transferred to Parkfield Works, Stockton-on-Tees. Private address, Low Church Wynd, Yarm-on-Tees, Yorkshire.

W. J. SAWYER is now at Rosario de Santa Fe, Argentine, superintending the erection of a Grain Elevator for Messrs. Spencer and Co., Ltd., Melksham, Wilts. Address, Hotel Britannia, Calle Urqinsa No. 1271, Rosario de Santa Fe, Argentina.

WM. JNO. TENNANT sailed from Southampton by the "St. Paul," on the 28th March, for the following business itinerary:—New York, New Orleans, St. Louis, Chicago, Pittsburg, Detroit, New York, Boston, Toronto, Montreal, Quebec, returning by "The Empress of Britain," which is scheduled to arrive at Liverpool on the 19th June.

S. C. WADDINGTON has been transferred with the staff of the Power Gas Corporation to Parkfield Works, Stockton-on-Tees. Private address, Low Church Wynd, Yarm-on-Tees, Yorkshire.

R. A. WHITSON will be in South Africa for some months. Address, c/o Mr. Harrison Gibson, Masern, Basutoland, South Africa.

FROM THE STARTING PLATFORM.

RAILS. The ultimate object in view in constructing a railway is to obtain a road on which all classes of traffic can be carried in vehicles. Such a road is known as the permanent way, and it is of the utmost importance that the parts of which it is constituted should, both as regards design and quality, be each of the best of its kind, and of all these parts the rails are of first importance as conducing to safety, smooth running, and to the comfort of the passengers using the line.

It is therefore not to be wondered at that the subject of rails has from the earliest history of railways, down to the present time, been almost continuously under the investigation of the metallurgist, the engineer and the chemist ; and so numerous and varied have been the changes made from time to time, dictated by experience and observation, and an ever increasing knowledge of the manufacture of steel, that these can only be alluded to briefly.

The Stockton and Darlington Railway, opened on the 27th September, 1825, had rails 9 feet in length, partly of wrought iron, weighing 28 lbs. to the lineal yard, and partly of cast iron weighing 57 lbs. to the lineal yard.

Some little experience was gained by the time the Liverpool and Manchester Railway was opened on the 15th September, 1830, and the rails adopted were of wrought iron, 15 feet in length, and weighing 35 lbs. per lineal yard. By this time the work of constructing railways became more active, and many forms of rails were designed, but the five representing those which came into general use were :—The Barlow rail ; the flat-bottomed or Vignoles rail ; the bridge rail by Brunel ; the double-headed rail by Locke ; the single or bull-headed rail.

The Barlow rail was designed with the idea of dispensing with sleepers, and may be said to have disappeared years ago. Rails of the Vignoles design are still used to some extent in this country, mainly in connection with light railways, but they have been entirely superseded on the main line of railway, chiefly it is presumed, because chaired roads prevail, although curiously enough, flat-bottomed rails are almost universally used in every

other country, substantially in the original form, but much changed as regards length, weight, and the contour of the section.

The bridge rail is still in use in this country, notably on the Central London Railway, and for special purposes.

A great number of double-headed rails that are not yet worn out must still exist on various railways, but it is doubtful whether the number of these is any longer being added to. This section is probably entirely superseded by the bull-headed rail, which may be said to be the universal section of rail used in this country.

It is difficult to state the precise dates on which important changes took place, but the following will give a general indication of the gradual development:—

	Length of Rails.	Weight per lineal yard.	
1840	varying from 12 to 15 feet	from 60 to 65 lb.	chiefly double-headed with bridge rail on broad gauge.
1840-1850	,, ,, 15 to 18 feet	,, 65 to 70 lb.	do. do.
1850-1860	,, ,, 18 to 21 feet	,, 70 to 75 lb.	do. do.
1860-1870	,, ,, 21 to 24 feet	,, 75 to 80 lb.	do. do. and also bull-headed steel rails introduced
1870-1880	,, ,, 24 to 30 feet	,, 80 to 85 lb.	do. do.
1880-1890	varying 60′ 0″, 42′ 6″, 36′ 0″ and 30 feet	,, 85 to 90 lb.	bull-headed.
1890-1900	,, 60′ 0″, 42′ 6″, 45′ 0″ ,, 36′ 0″ and 30 feet	,, 85 to 95 and 100 lb.	do. do.
1900-1908	,, 60′ 0″, 42′ 6″, 45′ 0″ ,, 36′ 0″ and 30 feet	,, 85 to 95 and 100 lb.	do. do. do. do.

Up to 1862 the rails were manufactured of wrought iron, but about that time rails made from steel by the Bessemer process commenced to be introduced, and these proving superior as regards wear, notwithstanding their heavy cost at that time, gradually replaced iron rails, and have for many years been exclusively used in this and every other country.

Taking £1 as the unit of cost per ton of rails at the present time, the following will give the relative cost from 1860, but it is necessarily very general and approximate:—

Relative Cost of Rails per Ton.

About 1860	...	Iron 1·05		
,, 1862	...	,, 1·05	...	Steel 2·50
,, 1865	...	,, 1·15	...	,, 2·05
,, 1870	...	,, 1·07	...	,, 1·65
,, 1875	...	,, 1·50	...	,, 1·50
,, 1880	...	——	...	,, 0·95
From 1880 to 1895 varying from			...	,, 0·70 to £0·75
,, 1895 to 1900 ,, ,,			...	,, 0·75 to £0·95
1908	...	——	...	,, 1·00

The Engineering Standards Committee issued their report on "British Standard Specification and Sections of Bull-Headed Railway Rails" in October, 1904, and a corresponding report on Flat-Bottomed Railway Rails in February, 1905. The specification and section do not differ greatly from that previously issued by the Railway Companies, but good work was effected in bringing all into line and assimilating the numerous little differences that existed. The sections standardised are bull-headed, 60 lbs. to 100 lbs. per lineal yard, flat-bottomed 20 lbs. to 100 lbs. per lineal yard, in both cases increasing in weight by increments of 5 lbs. The specification is amply full and clear, and gives all particulars of mode of manufacture, brands, chemical analysis and tests. For the bull-headed rail it is stated that the ultimate tensile strength shall not be less than 38 tons nor more than 45 tons per square inch, with an elongation of not less than 15 per cent. It is practically the same for the flat-bottomed rails, there being a slight difference in the figures. In both cases it is specified that the rails shall show on analysis that in chemical composition they shall conform to that given in the table below (letter A).

It could easily be shown that the constantly increasing weight of rails was occasioned by keeping pace with the ever-advancing weight of vehicles and axle loads, and the continuous increase in numbers and in the speed of the trains, and it must not be taken for granted that the last word has by any means yet been said. Indeed, since the issue of the Standard Specification there has been a greater demand than ever for harder, more enduring, and better wearing rails, yet at the same time equally safe and with no liability to brittleness.

That a higher quality of rail can be obtained is obvious, but at a greater cost, and in coming to a decision as to which should be recommended, all the qualities of safety, life, endurance, wear, cost, and whether there would be any saving or not in labour, and in the disturbance of traffic occasioned by the frequency or otherwise of replacements, must be taken into consideration.

TABLE OF CHEMICAL ANALYSES OF RAIL MATERIAL.

British Standard and other Rails on trial.

DESCRIPTION.	Carbon %	Manganese %	Silicon %	Phosphorus %	Sulphur %	Nickel %	Chromium %	Cobalt %
A British Standard	·35 to ·5	·7 to 1·0	0·1	0·075	0·08	—	—	—
B Special ...	0·67	0·73	0·25	0·040	0·047	—	—	—
C Special ...	0·49	0·77	0·02	0·021	0·059	1·45	·259	·247
D Special High Silicon	0·43	0·79	0·44	0·062	0·059	—	—	—
E Special ...	·39	·85	0·075	·097	·047	3·32	—	—

These special rails have not yet been sufficiently long in the road to give reliable figures as to their wear, and so far an approximate idea only can be given, as shown in the following table, which also gives the relative cost:—

Relative wear of Rails in lbs. and Unit of cost per ton.

	Description.	Wear in lbs.	Unit of Cost per ton.
A	British Standard	1·00	1·00
B	Special	0·75	1·40
C	Special	0·80	2·00
D	Special High Silicon ...	0·90	1·05
E	Special	0·70	1·60

From a number of tests to breakage the following have been selected as average figures, and although not conclusive, are decidedly hopeful :—

Results of Tests to Breakage.

A	Tensile strength	45·60 tons per square inch	18%	Elongation on 3 inches
B	,, ,,	53·5 ,, ,, ,,	15·25%	,, ,,
C	,, ,,	56·5 ,, ,, ,,	18·2%	,, ,,
D	,, ,,	50·3 ,, ,, ,,	17·8%	,, ,,
E	,, ,,	54·75 ,, ,, ,,	11·6%	,, ,,

Many other considerations enter into the manufacture of rails, such as, which of the various processes best meet the requirements of the case immediately involved, and the particular ore available; whether the process to be adopted shall be the Bessemer acid or the Bessemer basic, the Siemens acid or basic, or one or other of the open-hearth processes.

Then the result may be very considerably affected by the manner of mixing the metal and of pouring out. Take for instance the high silicon metal; the silicon is first eliminated to a low point in the conversion, along with the sulphur, and to bring up to the recommended proportion of silicon a specific amount is afterwards added in the form of ferro-silicon, and this with careful pouring out or teeming, to avoid piping, is freely admitted to have a decidedly beneficial effect.

Further, there are very important considerations as to the cogging and temperature during rolling, also the number of passes, and the time allowed between the first pass and the last, all of which affect the result.

Indeed, so complicated and delicate is the manufacture of steel and rails that the engineer's greatest safety lies in at all times obtaining ample, careful, and sufficient mechanical or physical tests.

ALEXANDER ROSS.

OBSERVATIONS IN GENERAL.

Nos réunions de cet été se tiendront en France du 27 Juin au 11 Juillet. Notre société compte en ce moment plus de mille membres, et nous avons l'espoir qu'un très grand nombre de ceux-ci donneront leur adhésion aux réunions en question et se trouveront en très grande proportion à la gare de Victoria le 27 Juin pour faire le voyage d'instruction et d'agrément projeté.

L'année courante a été pour notre société une année remarquable à bien des points de vue, et les réunions et visites d'usines portées au programme (déjà entre les mains des membres) promettent d'être les plus agréables et instructives auxquelles nous ayons jamais assisté.

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Ceux de nos members qui connaissent déjà la France et ses habitants profiteront certainement de l'occasion qui se présente pour renouer connaissance avec un pays et un peuple charmants à tous égards Les autres qui n'ont pas encore passé la Manche ne pourraient trouver meilleur moment pour faire leur premier voyage chez nos amis d'Outre-Manche.

* * * * * *

Je me souviens parfaitement de mon premier voyage en France, C'était l'année de l'exposition de 1900 et je pus, non sans peine, obtenir de mon contremaître la permission voulue. A cette époque mon salaire n'était pas très élevé et pour parfaire la somme quì m'était nécessaire, je fus obligé même de retirer la réserve de quelques jours qui m'était due au moment de mon départ. C'était faire preuve de témérité, parce que pour tout cela, je n'étais pas cousu d'or! Le contraste entre la petite ville manufacturière, noire, sombre, pleine de fumée, que je venais de quitter et la métropole française, propre et ensoleillée, fit sur mon esprit une impression ineffaçable. Je fis le voyage seul, je ne connaissais pas une âme en France, et à ce moment je ne savais que quelques mots de français. Je m'en suis quand même très bien tiré, grâce surtout à la courtoisie que l'on m'a temoignée à chaque instant, et suis rentré avec la ferme intention de refaire le voyage à chaque occasion possible.

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Cette impression personelle, je l'ai retrouvée chez tous mes compatriotes: un voyage en France et à Paris est invariablement un *premier* voyage, suivi de beaucoup d'autres, et en ferait-on cent que la première impression demeure.

* * * * * *

Le programme comme on le verra est bien rempli. Il comporte entre autres une visite aux usines Schneider, du Creusot.

Le Creusot compte environ trente mille habitants dont un tiers est occupé aux usines. Au commencement du xix[e] siècle l'usine—petite à cette époque lointaine—appartenait à des Anglais, Manby et Wilson. Il y a au Creusot près de la gare du chemin de fer, un vieux puits avec cheminée carrée appelé "Puits Manby" et à une distance d'environ cinq milles, le "Puits Wilson." L'usine n'a prospéré que lorsque M[r] Schneider l'a acquise vers 1830 ou 1840. Sous la haute direction de la famille Schneider elle n'a fait que marcher de progrès en progrès.

* * * * * *

Les autres usines et buts de visite portés au programme offrent tout autant d'intérêt que les usines Schneider; les Forges et Chantiers au Hâvre, notamment, où se construisent les navires de guerre et les navires marchands de la Compagnie Générale Transatlantique.

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En résumé, il n'ya qu'à parcourir le programme pour voir que l'instructif et l'agréable se trouvent tellement mélangés qu'il est impossible de les séparer l'un de l'autre. Grâce aux efforts de notre Président nous pourrons être certains d'être reçus à bras ouverts et de remporter du voyage la meilleure impression. Le soleil est sûr d'être de la partie et je suis persuadé d'avance que le sentiment unanime, lorsque nous saluerons une dernière fois du bateau, les falaises de Dieppe, sera celui de "Vive la France."

R. H. P.

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On the evening of Saturday, 21st March, the Caxton Hall was ablaze with light, and thronged with a merry throng—the Juniors were receptionising. The active ones among them tripped the light fantastic toe, and valsed and lancered and quadrilled to their heart's content, what time their more sedate colleagues exploited the respective trick-taking merits of hearts, diamonds, clubs, and spades. However much the gathering may have lacked in rank and fashion, it excelled in the presence of intellect and beauty, and the evening was voted "great."

The preliminaries of the formal reception, and the delightful concertette, were just long enough to enable the guests to find themselves, and their friends, and when the other items of the programme were reached, everybody was at home with everybody else.

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Members will learn with sympathetic interest that Mrs. Durham was prevented from assisting her husband in bidding them and their guests welcome, owing to her having been summoned to Frankfort-on-the-Maine, where her mother was prostrated by an illness, to which she has since succumbed. In the absence of Mrs. Durham, her niece—Miss Wilma Hickson—gracefully took her place.

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The whist drive was noted for the meteoric performance of G. T. Bullock, who, in his impersonation of a " winning gentleman," flitted from table to table like a busy (G. T.) B., gathering tricks all the way. He eventually secured first prize with a score of several thousand (more or less) points in front of everybody else. And he was one of the stewards, too! This should serve as a distinct encouragement to other Juniors to offer their services in like capacity next year.

*   *   *   *   *   *

How well he and the other Stewards—A. C. Beal, Hugh Calder, L. F. Ferreira, D. N. Hunt, J. W. Nisbet, Jas. Oswald, J. H. Pearson and Edward A. Pettit—worked to secure the success which everybody pronounced the evening to have been.

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Mrs. W. A. Tookey secured a popular victory for the best lady's score, receiving a charming little travelling clock as a memento of her success. Her husband, with his characteristic modesty, preferred to qualify for the lowest award, the " Order of the Golliwog," with which he was decorated in due form. The second lady's prize was gained by Mrs. Hardingham, whose score proved to be the nearest to a figure previously settled by the stewards.

It is reported that the Past and Present Councillors of the Institution held their annual dinner on the 24th March, with "Ye Olde Cheshire Cheese" as the rendezvous; that the number present was 31; and that the influence of Dr. Johnson's memory and other potent inseparable factors conduced to an exceptionally enjoyable evening being spent. Geo. T. Bullock occupied the chair, and the guests on this occasion were Frank R. Durham, as Chairman of the Institution, Wm. John Tennant, on his departure for the States, on a three months' business tour, and H. Cartwright Reid, on his return from Malta.

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Unfortunately, Mr. Reid had to write from Chatham expressing his great regret at not being able to join his fellow-guests, as his health was not sufficiently restored after the trying attack of enteric fever which he had to combat at Malta. Hearty were the wishes for his speedy convalescence.

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Our Honorary Member, Mr. Alexander Ross, Chief Engineer to the Great Northern Railway, has been good enough to occupy "The Starting Platform" for this month, reviewing the all-important subject of "Rails." We feel much indebted to him for his valuable contribution.

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The present issue of *The Journal* contains the names of candidates who if elected will necessitate our employing four figures to denote the enumeration of our membership roll. The exercise of this prodigality of notation has been an ambition with many a member for a long time past. Let us exchange congratulations on our millenary, and at the same time remember the increasing responsibilities which this distinction, as an Institution, imposes upon us. *Noblesse oblige.*

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The parent Institution in Great George Street, aged 90, is following the example of its youngest child in Victoria Street, aged 24, in forming a Building Fund. The circular setting forth the circumstances which have led to this step, the principal one being the proposal to sell the present building and site to the

Government, concludes "Promises of support to the Fund have been already given by Past-Presidents and Members of the Council in accordance with the list appended hereto."

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The list contains thirty-four names, and the amounts suffixed range from ten guineas to five hundred pounds. For the sole information of our members we have gone to the trouble of comparing the figures, and find that already, although our Fund was inaugurated some months ago, there is a considerable discrepancy between the respective totals, to the advantage of our elders, which, as respectful children, we must say is just as it should be, but our Fund must grow with us!

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A Special General Meeting of Corporate Members is to be held on the 3rd April, to authorise the Council to proceed with the sale of the building and site, and to consider, and if approved adopt, alterations to the By-laws whereby (1) those transferred to full membership shall pay a fee of £10 10s., and (2) those in future elected in the first instance as full members shall pay £21.

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Sir John Wolfe Barry (Past-President) has kindly presented to our Library two copies of "Cinquantenaire," being the record, in French, of the Jubilee celebrations of the Societe des Ingeniéurs Civils de France, of which our present President, M. Canet, is a Past-President.

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Mr. Dugald Clerk, having been President of our Institution, is experiencing the inevitable consequence of becoming the recipient of other distinctions. He has been recently elected a Fellow of the Royal Society. Our members will unite in offering him their sincere congratulations. Mr. Clerk has also been elected President for 1908 of the Incorporated Institution of Automobile Engineers.

DISCUSSION ON "THE ARCHITECT AND THE ENGINEER."

[We are indebted to Mr. A. H. Belcher, Hon. Secretary of the Discussion Section of the Architectural Association, for the following.—Ed.]

Mr. W. Wonnacott said he considered the object of both professions at every step should be to consult the interests of the client. The suggestion of the author, to extend the existing registers, was a good one, but he thought far more could be done by private introduction. With regard to the idea of a Committee of Selection, he failed to see how that could work. He presumed the idea was that the Institution or the Architectural Association would have just an announcement that they could find men when they were required.

Mr. Travers remarked that he considered that a Committee of Selection would be open to serious difficulties ; one man's ideas of what sort of men the engineer needed would be diametrically opposite to another man's ideas.

Mr. F. R. Durham said that the whole question seemed to turn upon ethics and fees. As an engineer, he thought engineer's fees should be established on some good basis, but this had never been arranged. The result often was, he thought, that a client, not knowing how much the fees should be, would not employ an engineer at all, but would go direct to the manufacturer. He also thought that the architect's fees should be raised to include the fees of engineers, who would be paid by the architect.

Mr. J. H. Pearson thought that architects, in their buildings, often could not see the work from an engineer's point of view. Architects should have a general knowledge of engineering, and likewise engineers a general knowledge of architecture.

Mr. Hamp considered it impossible to expect one man to understand all the details of water-supply, steel construction, heating and ventilation, &c., and therefore the consulting engineer should be called in to deal with these. With regard to the question of fees, there was no doubt that the client had to pay them, whether he went to the commercial man or to the professional man, and

he did not think it advisable to pay them out of the quantity surveyor's fees.

MR. FORSTER felt the architect should work with the engineer, and not leave the engineer to come along afterwards, and thought they should study construction as well as the artistic side of their buildings.

MR. R. MARSHALL said the meeting seemed to be agreed that the encyclopædic individual was a total impossibility. It was not possible for one individual to carry out all the different branches of work on his own responsibility. That being so, they might take it there were three ways in which the work could be done:—(1) By the architect. (2) By the architect in conjunction with the manufacturing contractor. (3) By the architect in conjunction with the consulting engineer.

The third was that which he considered should be adopted, and he thought that it should be clearly understood that the consulting engineer should be employed, whether the works were a hospital, jetties, walls, or a bridge, and that he should be employed with definite fees, the contract amount comprising the architect's, the engineer's, and the quantity surveyor's fees. This arrangement with municipal bodies would give a line of demarcation, and relieve the borough engineer of work which should not rest upon him.

MR. K. GAMMELL, the Chairman, said that he was associated once in his work with an engineer, and the client paid the engineer's fees without a murmur. With regard to the suggestion of collaboration, he was not a believer in registers, and thought much more could be done through the Secretary of the Junior Institution of Engineers in an informal manner.

CORRESPONDENCE ON "THE ARCHITECT AND THE ENGINEER."

MR. E. G. S. VAUGHAN (Member) wrote:—Whilst much regretting my inability to have been present at the joint meeting, I have read with pleasure Mr. Waldram's most interesting paper, as published in our Transactions.

I most strongly deprecate the prevailing custom of allowing the steelwork contractors to quote on their own designs, for however capable their staff may be in designing (and they are very capable usually), competition is so keen now-a-days that it is, as a rule, the contractor who has cut his steel work down to the finest possible margin, and frequently on the wrong side as regards safety, who obtains the order.

I cannot agree with the author's statement that the manufacturing engineer has "carte blanche" as regards price, for nearly all steel work at the present time is put out to the keenest possible competition, and it is on this account, possibly, that the successful competitor tries to do away with any expensive form of construction, and use up, as far as may be, the sections that he may have in stock, or can easily obtain, and thus cheapen the cost of production. The finished structure may not quite accord with the ideas of beauty possessed by the architect, who prefers curves and shaped plates, but does not seem to realise the extra expense involved. The design as submitted may be all that is necessary to do the work that is required of it; being, as a rule, hidden, the artistic and expensive finishing touches would be lost.

The author seems to consider that the average constructional engineer knows nothing about constructing in brickwork, and is only able to design and take out his quantities in steel or reinforced concrete structures; I do not agree with him in this assumption at all, for to me it seems that a constructional engineer should be experienced in all the known methods of building construction, timber structures, brick, stone, &c. The examples, which he quotes, seem to me scarcely to apply, for the engineers in question were not constructional men, and they are, I think, quite as bad offenders as some architects, in accepting work of which they understand very little. The mistakes in the quantities seem to have been due, not to the inability of the engineering draughtsman to take them out accurately, but to the

great carelessness of the typist, and unpardonable want of supervision on the part of those in authority.

These examples, in my opinion, point to the fact that a constructional engineer should have been called in, as engineers recognise that to cheapen production in a manufactory the machines must be put in the right places and the building made to suit, not the position of the machines made to suit the shape of the building.

The engineer seems to recognise more than the architect that the building is only put up for dividend-earning purposes, and not as an example of fine art.

The author states that the architect's detail drawings are ample; this as a rule is so, for any reliable architect, but I believe it is not unusual to leave them to the builder's foreman or clerk of works, and it is not an unknown thing for the architect's assistant to go round to the site and mark out some details on to the finished surface of the plaster.

I sincerely hope that the happy millennium to which the author looks forward may soon come, as then, with the architect placing his work in the right hands, the consulting constructional engineer may have a brighter outlook than he has at the present time.

MR. S. M. HILLS (Member) wrote:—The remarks which I am about to offer refer to what is perhaps one of the smaller sections in which the engineer and the architect are likely to become associated, viz., those cases in which the building is to be illuminated by electricity. The many kinds and qualities of cables and electric fittings, lamps, &c., present a somewhat bewildering choice to anyone who is not able to devote a considerable amount of time to studying the matter.

There are competent electrical engineers who will draft a specification and inspect the work (under arrangement with the architect) whilst it is in progress. I do not allude to the consulting electrical engineers who have offices in Westminster, for I venture to think it is hardly possible that their terms would be acceptable in such cases, and they probably would not care to consider work of such a character. Two advantages resulting from this method are that the architect and his client obtain the benefit of satisfactory work, and that the contractor will probably receive instructions from an engineer in a better spirit than he will

from an architect, whom he may regard as an intruder. The engineer will certainly see that the work is carried out perfectly, which the architect, from his necessarily inadequate knowledge of technical details, could not be expected to do.

I heartily agree with Mr. Waldram's suggestion that the architectural and engineering societies should help each other, and hope that at an early date the Architectural Association and the Junior Institution of Engineers will inaugurate a system and thus set an example to other societies.

MR. P. J. WALDRAM has contributed the following further observations on the subject of his paper :—

Extension of Committees of Selection to form Bureaux of Technical Information.—Committees such as have been suggested would also be eminently fitted to organise the speedy dissemination of technical information possessed by the members at large to individual members requiring it. To become, in fact, bureaux of technical information.

The author holds very strongly that the two Societies are not properly fulfilling their functions, and are not giving their members proper value for their subscriptions unless and until they have the means of rapidily obtaining for any member in a difficulty the best advice and help which can be afforded by any other members who are fitted to render such assistance.

Such machinery has been in existence many years in connection with the Surveyors' Institution. A member who is in a difficulty posts or telephones it in the form of a question to the Secretary, who at once duplicates it and forwards copies to different members known to be experienced in the class of work involved. Their replies are posted to the enquiring member at once, and the question and replies are published in the next issue of the Professional Notes for the benefit of the whole of the members—the question anonymously, but the replies with the names of the answering member. The replies are given quite gratuitously, and come as freely from members of the highest professional eminence, as from the rank and file. The questions and answers are indexed, and form a most valuable library of information in the most interesting and readable form. But the

enormous benefit is the sense of security which the system gives to every member, the feeling that in any difficulty, however great, such a fund of ready help can be drawn upon without the slightest delay, without payment, and with a minimum of trouble.

What the Surveyors' Institution is doing and has done for many years the two Societies now meeting together ought to be doing with equal energy. The Junior Institution of Engineers has recently adopted the system of publishing questions and answers. The Discussion Section of the Architectural Association also have their question time at the commencement of the meetings, but the answers are only such as can be given on the spur of the moment by such members as happen to be there in time, and the answers are not published for reference.

The author ventures to think that the small committees he has suggested might well continue the work of bureaux of technical information—not of information personally possessed by themselves, although that would in the nature of things be of no small value, but of information possessed by the bulk of the members, by their friends, and contained in the books, technical journals and proceedings which so often lie buried and useless in the libraries. The respective societies should regard such bureaux as their most valuable asset and their work as being the most vital and important of the Institution's activities; every assistance, personal, clerical, and, if necessary, financial, which the energies of the Institution can possibly spare should be given to them, and given readily. The author believes that bureaux of technical information would attract and retain far more members than the best possible papers and the most attractive visits.

An obviously first task of such committees or bureaux would be the compilation of confidential registers of the knowledge, work, and experience of members; a work of great value if kept properly up to date. Then later, subjects of importance might be selected, and members who had made a speciality of such subjects might be invited to form sub-committees to tabulate *prècis* of works of reference thereon to be found in the societies' libraries and elsewhere, and to note papers and articles on the subjects which would otherwise be buried in the back numbers of proceedings and of technical journals.

Then similar joint committees of the two Institutions might well be formed to similarly study and record for speedy refer-

ence information on subjects of importance to both professions, in which the available data is now scattered and obtainable only with difficulty such as the economical design of ordinary structural steelwork, reinforced concrete, the lighting of buildings considered photometrically, the safe loading of brick walls and piers and foundations, approximate estimate, and similar subjects.

Present practice of Quantity Surveyors acting as Technical Advisers to Architects, and Suggestions for its Improvement.—The author has disclaimed any intention of suggesting that the function of engineer and architect can be combined in one and the same person, but it must not be forgotten that there is an important class of professional men—the building or quantity surveyors—who are often called upon for advice upon engineering matters in connection with buildings, although their training and work give them no title to speak thereon with authority. Possibly on account of the extensive curriculum of education called for by the professional examinations of the Surveyors' Institution, architects have found that the range of knowledge possessed by well-trained surveyors is very wide, in fact, pretty well co-extensive with the requirements of modern building practice, and architects have naturally become accustomed to pass on all their difficulties to their surveyors.

When taking out the quantities the surveyor reviews the construction down to the smallest detail, and attends to all the minutiæ of the specification. He corrects all mistakes in drawing and figuring, advises as to materials, makes approximate estimates, calculates the payments on account, and values the variations. In addition to being above all an expert in construction and sanitation, he must be a sound lawyer, able to act as solicitor, counsel, special pleader or judge; his knowledge of the statute and common law of easements, dilapidations, leases, land, and of the London and Provincial Building Acts and local bye-laws, has to be exact; and he must also be an expert valuer with a particular knowledge of builders' prices and materials. Considering also that under the system of office pupilage he is usually forced by an astute employer to devote the first and best years of his youth to squaring dimensions, writing letters and to general office drudgery, it is not surprising that very few quantity surveyors can qualify in any of the branches of

engineering required in connection with building work, although their position of technical advisers to architects puts them directly in the way of securing such business.

At the same time, men whose work after the first two or three years makes such constant and continuous calls upon their intelligence would be really better fitted to qualify also in some branch like steelwork than those whose work keeps them in less severe mental training. Provided always that after leaving school equipped with a good sound training in physics and science, eighteen months or more were saved from the squaring dimensions stage, and devoted to say twelve months at a good engineering college, and six months practical work. Failing such a training it would appear advisable for them to secure as before suggested the services of collaborating engineers if the architects fail to do so.

THE TESTING OF GAS ENGINES.

CREATION OF LOCAL SECTION AT BIRMINGHAM.

The Sixth Meeting of the Twenty-seventh Session was held at the Royal United Service Institution, Whitehall, on Thursday, 20th February, 1908, the attendance being 72. The Chairman, Mr. Frank R. Durham, took the chair at 8 p.m., and the minutes of the previous meeting were read, confirmed, and signed.

Before proceeding with the business of the evening, the Chairman made feeling reference to the decease of Mr. J. Macfarlane Gray, who, elected in 1890, was held in such high regard as an Honorary Member of the Institution. As a mark of respect to his memory, on the proposal of the Chairman, the members rose silently from the seats.

It was announced that since the last meeting the following had been elected to the Institution, viz. :—

Honorary Members.

Capitaine E. Ferber ...	Paris.
M. Julliot	Paris.
Count de la Vaulx	Paris.

Members.

Herbert Paine Bray	... ...	Willesden Green.
William Henry Goodman...	...	New Cross
Henry O. Jones ...	... ...	Dalston.
Bernard Adalbert Kupferberg	...	Westminster.
Polybius Loisu ...	... ...	Cardiff.

Associates.

Henry Humphreys	... ...	Ascot.
Phillip Henry Reeves Jephson	...	South Kensington.

The Chairman announced that the Council had at their previous meeting, granted a petition for the formation of a Local Section at Birmingham, and suggested that London Members having engineering friends there should communicate with them with a view of their assisting in the movement.

A paper, entitled "Practical Notes on the Testing of Gas Engines" was read by Mr. Gilbert Whalley, Member of Council, of Walton-on-the-Naze.

The discussion was opened by Mr. W. A. Tookey, who also proposed a vote of thanks to the author for his paper. The motion was seconded by Mr. Stanley Hughes and carried by acclamation. The other speakers were Messrs. G. Lygo, C. G. Evans, R. Brewer, W. Stevens and R. H. Parsons.

The author having replied, the proceedings terminated with the announcement of the ensuing meeting on 13th March, when a paper on the "Purification of Water" would be read by Mr. Geo. H. Hughes, and of the ensuing visit on the 22nd February, to King's College, London, for an inspection of experimental apparatus, &c.

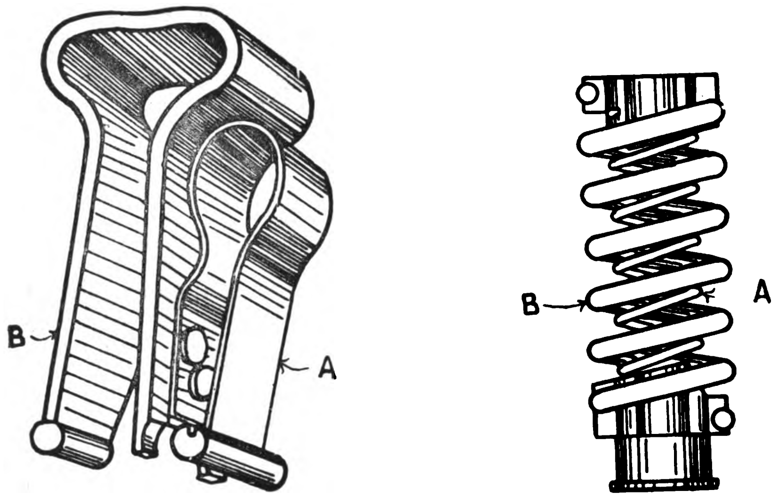
BIRMINGHAM LOCAL SECTION.

The Fifth Meeting of Birmingham members and friends was held at the Headquarters of the Electrical Engineers Volunteers, as previously, on Thursday, 20th February, 1908. Mr. E. G. S. Vaughan (member) took the chair at 8 p.m. There was an attendance of 10, of whom 8 were visitors.

The minutes of the previous meeting having been read, confirmed, and signed, Mr. R. B. A. Ellis read the paper entitled "Practical Notes on the Testing of Gas Engines," presented to the Institution by Mr. Gilbert Whalley, after which a vote of thanks to the author was proposed by Mr. A. C. Knipe (visitor), seconded by Mr. Maundrell (visitor) and carried unanimously. Mr. Knipe mentioned that a method of finding the dead centre in connection with ascertaining the length of stroke, was to turn the engine round until near the forward dead centre, mark the fly-wheel, and measure the amount of piston projecting, then turn the fly-wheel until the piston occupied the same position on the return stroke; again, mark the fly-wheel; the bisecting point between these two marks would give the dead centre exactly. He thought the expression "sound of explosion" should be more correctly "sound of exhaust," and would like to know if it was strictly correct to say that with a higher compression there was a lower cylinder temperature.

Mr. O. D. North considered the importance of the subject was very great, particularly when the increasing use of gas engines for country houses was taken into account. He also drew attention to the recent report by Prof. Burstall, of the high efficiency which he had obtained from a gas engine, and mentioned the possibility of counting the explosions by placing the hand on the cam shaft; the extra work done in opening the exhaust valve after an explosion stroke caused the cam shaft to whip to an extent easily felt in an engine with a long cam shaft.

Mr. Walshe drew attention to the growing use of water brakes, such as the Heenan and Froude and Dr. Morris and Lister's eddy-current machines; also the simplex indicator, with the double spring (see illustration below), one light and the other heavy, the former recording to a larger scale the lower pressures, then closing up, and the heavier spring recording the higher pressures to a smaller scale. He did not understand the expression "reversal of pressures" mentioned under "pre-ignition," as on the compression stroke the connecting rod was in compression, and when firing occurred this was simply increased. With reference to the use of lead plates for load purposes, when testing with a dynamo, he had had experience with the use of cast-iron plates, which were equally good and less expensive.



Double Spring for Indicator.

The Chairman believed the paper would be found of considerable practical value, as owing to its length the author had been able to enter very fully into the details of the subject.

A vote of thanks to the Chairman, proposed by Mr. Luijks, seconded by Mr. Knipe, was carried unanimously, and the proceedings closed with the announcement of the ensuing meeting on Monday, 16th March.

"PRACTICAL NOTES ON THE TESTING OF GAS ENGINES."

By GILBERT WHALLEY (Member of Council), of Walton-on-the-Naze.

Read 20th February, 1908.

Extended Application of Gas Engines.—With the introduction of producer gas, power users began to realise that the gas engine was a machine which would give reliable results for a minimum cost of working. It is not surprising, therefore, that the gas engine is now to be found in industrial concerns of practically every kind, and that increasing numbers are being put down every year in factories and works all over the world. It is with the testing of such engines that the author proposes to deal.

Objects of Testing.—The determination of power developed, measurement of quantity of fuel consumed, checking of oil and water used, and testing for faults in case of a breakdown or other trouble, may be mentioned as the principal objects of testing.

Methods of Testing.—These depend entirely upon the object of the test. For a complete test the following points need consideration:—(1) General inspection of the engine and surroundings. (2) Detailed inspection and measurements of bearings, &c. (3) Verification of valve settings and lifts. (4) Determination of power available at pulley or flywheel. (5) Determination of power developed as shown by the indicator. (6) Determination of fuel consumption. (7) Memorandum of details connected with water circulation. (8) Method of preparing report.

In a busy factory it frequently happens that the dinner interval is the only time available in which to take the necessary observations on the engine, as it must be kept regularly running during working hours. The required data has therefore to be obtained expeditiously, necessitating considerable forethought in the preparations for the test.

General Inspection of Engine and Surroundings.—The question of the site of the engine may not at first appear to be of much

importance, consequently the engine is often merely "dumped" in some out-of-the-way place that cannot be used for any other purpose near the point where it is desired that the power should be applied, without much regard to the necessity of adequate space for the attendant, &c.

There should be a clear gangway of 3 feet right round the engine, except for the space occupied by the belt. Whenever possible the engine should be fixed so that the belt drives away in a forward direction; that is to say, it should not be taken from the pulley back past the cylinder, but should run in the opposite direction, especially so when it is necessary to place a pulley on the cam shaft side of the engine.

The engine foundation should consist of a bed of good concrete, the thickness of which will of course depend upon the nature of the ground. In bad ground it is sometimes necessary to place substantial footings at the bottom of the foundation in order to get a firm job. The shocks to which a gas engine is subject make it imperative that there should not be any movement at the foundation. In the case of an engine with an outer bearing, the foundation for the latter should be part and parcel of the main foundation, for if not, should any settlement of either foundation occur, the crank shaft will give trouble, either with hot bearings or by actual fracture. A wall box should never be used for an outer bearing. It is advisable to place a piece of sheet lead between the engine base and the top of the foundation, arranged with a beading round the edges, so that oil is prevented from working its way under the frame and causing trouble by rotting the concrete bed. It is within the writer's knowledge that the absence of this precaution has been the direct cause of the fracture of several crank shafts.

When the engine is served by a gas producer, the latter should not be placed in the same room, but in some fairly open and easily accessible position. There is always a certain quantity of dirt and grit inseparable from the producer, and this is liable to damage the bearings and other wearing parts of the engine.

Detailed Inspection and Measurement of Bearings, &c.— When the power of an engine, or the strength of any individual part are in dispute, the necessity of careful measurement of the separate portions arises, and it is advisable to use some recognised method in dealing with these measurements, so that it may be

possible to compare the various makes of engines, and also to readily check the design. The following form of schedule has been found satisfactory :—

Inspection made by............................, for M.........................,
at......................, on (Date)
Engine maker and number of engine...
Type of engine (state whether horizontal or vertical, single or double acting), number of cylinders, two or four cycle, and town or producer gas..... ....
Method of governing...
Ignition...
Diameter of cylinder...
Length of stroke...
Speed in revs. per minute..
Piston speed in feet per minute..
Main bearings, diameter and length.....................................
Outer bearing (if any) diameter and length.............................
Crank pin bearing ,, ,, ...
Piston pin bearing ,, ,, ...
Length of connecting rod ,, ,, ...
Distance between centres of main bearings..............................
,, ,, ,, middle and outer bearing....................
Connecting rod, cap bolts, diameter and thread.........................
Crank web, diameter, or width and thickness............................
Flywheels, number, diameter and width, details of keyways...........
Cam-shaft diameter...
General remarks..

The valve settings and water circulation details are not included in the above. They form such important factors in the good working of an engine that they will be dealt with separately later.

The measurement of the diameter of the cylinder is a most important part of a gas engine test, and the utmost care is needed that it should be exact. To measure it by means of a rule placed across the end of the liner is not sufficiently accurate, neither can it be accurately measured from a spare piston ring. A pair of inside calipers should be used to take the diameter, but calipers of the required size are not always available. In that case two strips of wood, each chisel pointed at one end and a little shorter than the diameter of the cylinder, may be used.

With the connecting rod out of the way as far as is possible, the pieces of wood are inserted, held together, and slid apart until the chisel points just touch the wall of the liner; they are then rotated in a vertical plane, as far each way as the connecting rod will permit, care being taken that they are gripped well together. Two or more lines are scribed across both of them. They can then be taken to some convenient bench, and with the lines coincident, can be carefully measured, and the diameter of the cylinder thus read off fairly accurately.

When it is required to measure the diameter of a cylinder with great precision, the piston must be taken out and a micrometer gauge employed. The vertical and horizontal diameters of the front end, of the middle, and of the back end must be taken. It is sometimes necessary to measure the piston in the same manner.

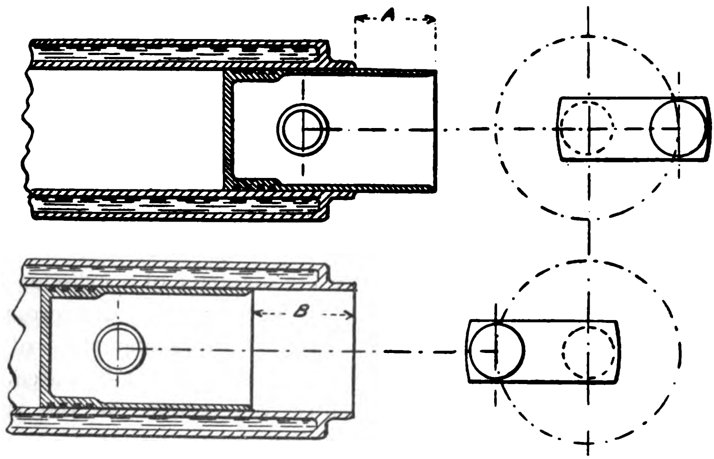
The measurement of the length of stroke also requires particular care. It cannot be obtained by placing a rule along the web of the crank and doubling the dimension, as it is impossible by eye to judge the centres of the crank-pin and of the crank shaft.

The correct method is to set the crank horizontally on the out centre by means of a spirit level, and to measure the distance A, Fig. 1, that is, from the front of the piston to the front edge of the liner; then to bar the engine round until the piston is right in, and the crank level again; then to measure from front of piston to front of liner, B, Fig. 2. The sum of these two dimensions (A and B) will be the exact stroke. It might be imagined that under the influence of the standardization movement, makers would have adopted regular dimensions for diameter of cylinder and length of stroke, but it is found that both these are frequently above or below even sizes.

The most convenient method of ascertaining the speed in revolutions per minute is by means of the ordinary speed counter, applied at the end of the crank or cam-shaft. When, as sometimes happens, it is not possible to get to the end of the crank-shaft, owing to keys, pulleys, or guards, and the cam-shaft is resorted to, it should be remembered that this shaft only revolves at half-speed. The same remark applies when counting with the hand against one of the cams or valve levers. This method, however, is not to be recommended, for however careful one is,

FIG. 1.

FIG. 2.



Measurement of Length of Stroke.

it is exceedingly difficult to avoid error amid the noise and distracting conditions inseparable from an engine room.

In ascertaining the speed it is advisable to count for several minutes and then take the average. When a long test is on, extending over say a number of hours, it is useful to employ a tachometer, which, driven from the end of the crank-shaft shows at a glance the revolutions per minute, and denotes every variation in the speed. It is advisable, however, to verify the readings of the tachometer periodically by the ordinary methods of speed counting.

For ordinary gas engine practice the piston speed (length of stroke in feet × revolutions per minute × 2) is usually found to be somewhere about 600 feet per minute. It is not advisable to run at a much higher piston speed than this, although some of the latest engines are designed for speeds approaching 700 feet per minute, and in some cases even higher.

The necessity for the measurement of bearings is apparent in such cases as where trouble occurs through running hot, and the design of the engine is questioned; it may be suggested that the bearing surface is not adequate.

To make a thorough inspection of the main bearings, it is necessary to remove the brasses, but this involves raising the crank-shaft, which should not be attempted without proper

lifting tackle. This is seldom available when required at short notice, and then the inspection must be carried out with simply the caps removed.

After uncoupling the large end of the connecting rod to take the dimensions of the crank-pin bearing, care must be exercised when lowering the connecting-rod after the cap is removed. When drawing the piston, in order to inspect and measure the piston-pin bearing, a block of wood should be placed in the engine frame and the piston gently lowered upon it to avoid liability of fracture.

Checking of Valve Settings and Lifts.—There are two methods of checking the valve settings and lifts; one by comparing the points of opening and closing of the valve with the position of the piston in the cylinder, and the other by comparing with the crank angles. The author's usual procedure is to combine both these methods.

Dealing first with the air valve, it is necessary to bar the engine round until the valve is just about to open. This position is found by observing that all clearance has been taken up between the cam and its roller, and also between the valve lever and valve stem, and that no movement of the valve has yet begun. At this point of opening, the piston will be found to be nearly at the back extent of its travel and on its inward stroke. The distance of the front of the piston in the liner and also the crank angle should be then accurately measured. The engine should then be barred until the valve has attained its maximum lift, which should be measured and the angle taken. The engine should then be barred round until the valve closes, care being taken to see that the clearances are still taken up and that the valve is home on its seat; the distance the piston is out of the liner should then be measured and the crank angle taken.

The exhaust, gas and timing valve (if any) are checked in the same way. If the engine is a large one and difficult to bar round, all the valves may be checked during one operation.

The instrument usually employed for measuring the crank angles is a spirit-level, semicircular in shape, carrying a pointer, and mounted in a frame in such a manner that it may revolve through 90°. It is placed on the web of the crank and the movable portion is rotated until the spirit level is horizontal. The crank angle is read off from the pointer indicating upon a

circular scale of degrees marked on the frame of the instrument. The disadvantage of this method is that owing to the imperfect lighting of engine rooms it is usually difficult to see when the spirit level is precisely horizontal.

A very handy instrument which overcomes this difficulty consists of a stand carrying a scale of degrees, with a pendulum (supported from the centre of the dial) which acts as a plumb line, and so remains vertical at whatever angle the crank may be. As the scale moves up or down, it records the angle at which the crank is placed.

Valve settings will be found to vary slightly, according to the make of engine and to the gas used (whether town or producer). It is therefore impossible to lay down any hard and fast rule for the exact settings, but the following diagrams give a fair average of present practice. (Fig. 3.)

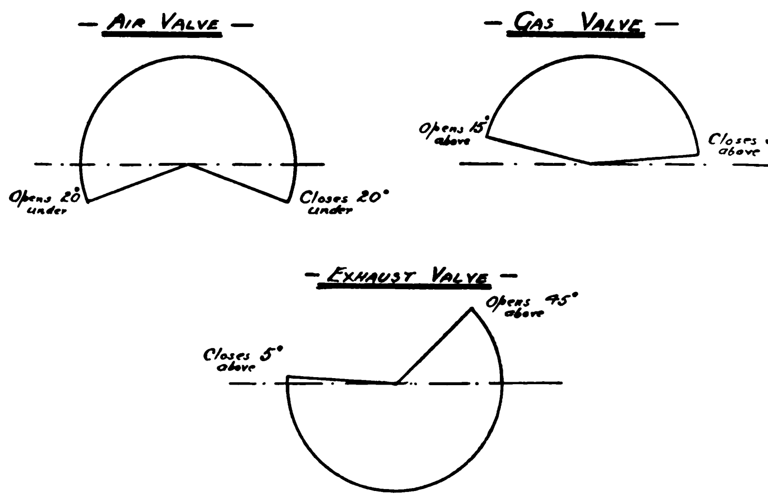


Fig. 3.—*Setting of the Valves.*

The above diagrams refer to engines with connecting rod of five times the crank throw, and apply to town gas only. For engines working on producer gas the setting of the gas valve is altered slightly, being opened at the in centre and closed at the out centre.

It will be noted that the air valve opens before the exhaust valve closes; thereby pure air can sweep through the cylinder,

away through the exhaust valve, and so thoroughly scavenge out all burnt products due to the previous explosion.

The ignition is so timed that the full force of the explosion occurs just when the crank rises above the centre, and the correct setting can only be determined with the aid of indicator cards. With the ordinary mushroom-shaped valve, the lift is usually designed to be one quarter of the diameter of the valve, although in some cases the diameter is increased beyond the usual practice, so as to change the velocity of the gases passing the valve, and in that case the lift is made proportionally smaller.

The correct method of measuring the lift is by making a mark on the valve stem and with a pair of calipers, taking the dimension from this mark to the end of the valve guide. The lift cannot be obtained by measuring the "hump" on the cam, as this does not allow for clearances, and also the valve levers transmitting the motion from the cam to the valve are not always made with the same leverage.

Determination of power available at pulley or flywheel.—In determining the power available a brake may be employed, or a dynamo may be driven from the engine and the electrical horse-power developed calculated.

The latter method is usually found to be sufficiently accurate for the majority of ordinary tests. It consists of driving a loaded dynamo, which should be fitted with a voltmeter and ammeter. The capacity of the dynamo should of course be greater than that of the engine, so that the engine can be tested right up to the pulling up point. A convenient way of loading the dynamo is to run the cables to two lead plates, each fixed to a piece of wood, and arrange them over a tub of water in such a manner that the resistance can be regulated by the distance the plates are immersed in the water. The output of the dynamo can be measured from the readings of the voltmeter and ammeter, and thus the electrical horse-power developed can be arrived at. Testing with a dynamo cannot, however, be relied upon to give exact results, as the efficiency of the dynamo and belt slip should be taken into account. The loss due to belt slip can usually be estimated as being between 3 and 5 per cent. With a well-designed dynamo driven by a belt of sufficient width, every 600 to 640 watts shown by the electrical measuring instruments can be taken as equal to one brake horse-power.

For more accurate results it is advisable to test by means of a brake, and arrangements for these brake tests vary according to circumstances. For instance, if it is required to find the maximum power an engine is capable of developing, without regard to the length of time at which it can run at that power, the simple rope brake on the flywheel is sufficient. If the engine has to stand a brake test of so many hours duration, special arrangements must be made for cooling the brake, as the heat generated by friction is liable to cause a fracture of the flywheel.

The most usual methods of carrying out a brake test are by means of (1) the prony brake, and (2) the rope dynamometer. The former, which is the method usually employed on the Continent, consists of a pulley keyed on to the end of the crank shaft, and clamped in between the upper and lower portions of the brake by two bolts and nuts, as shown in Fig. 4. The upper arm of the brake is extended and loaded with weights or by a spring balance. With weights it is necessary to arrange two stops to restrict the motion, as there is a tendency for the arm to oscillate, but, with a spring balance, only one stop is required and an eye bolt to the floor.

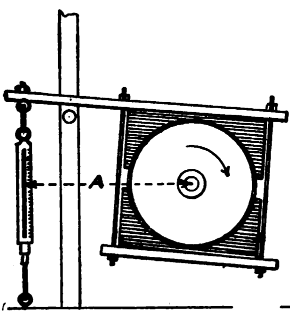


Fig. 4.

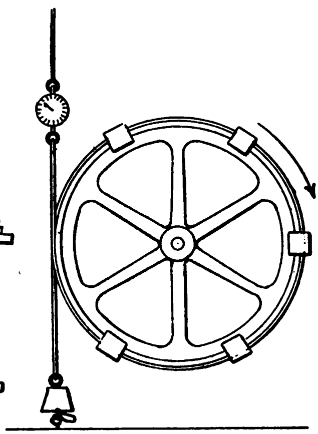


Fig. 5.

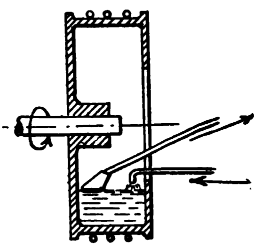


Fig. 6.

Determination of Brake Horse-power.

To compute the power developed the following formula is used:—B.H.P. $= \dfrac{N \times 2A \times \pi \times W}{33{,}000}$. Where N = revolutions

per minute; A = distance from centre of shaft to centre of pull in feet, measured at right angles to the direction of pull; W = weights in lbs. or reading of spring balance in lbs. It is necessary to make allowance for the weight of the arm, and of the balance, and this can be done by extending another arm of the same weight on the opposite side.

The rope dynamometer, as usually employed in this country, consists of one or more ropes placed round the circumference of the flywheel, and held in position by blocks of wood attached at intervals. The load is applied by hanging weights at the lower end of the rope, as shown in Fig. 5. To the other end a spring balance is attached, having either a screw adjustment, or slung over a pulley and fixed to the roof or some secure position. With this method it is advisable to anchor the rope carrying the weights, so as to prevent them being carried over the wheel. In place of weights, another spring balance anchored to the floor may be used.

The power developed is shown thus:—

$$\text{B.H P.} = \frac{D \times \pi \times N \times (W - w)}{33{,}000}.$$

Where D = diameter of wheel in feet; N = revolutions per minute; W = weights or reading on lower balance in lbs.; w = back pull as shown on upper balance in lbs.

The figure to be used for D in the formula is the diameter of the wheel plus the diameter of the rope, in order to take into account the thickness of the latter. Allowance must also be made for the weight of the lower balance and fittings.

The greatest care is required when working with this type of brake to prevent all the gear being carried round with the wheel, especially when starting up; probably the best way is to get the engine running first and then slip the gear on.

With either the rope or prony brake, it is not possible to run for more than a few minutes at a time owing to the heating up of the brake-wheel. For tests of longer duration therefore, it is necessary to introduce some method of cooling. A special hollow drum may be keyed on to the crank-shaft to carry the brake ropes, and provision made for a supply of water to the inside, as shown in Fig. 6. The waste is taken away by placing a scoop just on the water line, to act as an overflow. With such

an apparatus fitted it is possible to run a test for practically an unlimited length of time.

In making a protracted brake test, records should be taken of every change in the load and consequent variations of the speed, and, if possible, indicator diagrams should be taken at the same time. The latter are particularly necessary when running on producer gas, as the effect of every change of load and speed has a marked effect on the gas producer, which the diagrams will show.

Determination of Power from Indicator Diagrams.—Referring to the well-known formula for computing the indicated horse-power of an engine, viz. :—$\frac{P \times L \times A \times N.}{33{,}000}$ Where P = mean pressure in lbs. per square inch ; L = length of stroke in feet ; A = area of piston in inches ; N = number of explosions per minute, to obtain the factor P an indicator diagram is required, and in this connection the author would refer members to Mr. L. F. de Peyrecave's paper on gas engine indicators, which was read before the Institution in 1906 (Transactions, Vol. XVI., p. 264).

For the attachment of the indicator, a direct communication into some part of the combustion chamber is arranged, which is furnished with a screwed plug. On high compression engines this plug should be made of sufficient length to occupy the whole of the passage, in order that there be no cavities in which flame may linger, and so cause early firing of the charge. This plug will usually be found to be screwed $\frac{3}{4}$ inch Whitworth, but a gas thread is occasionally met with. The indicator cock is often made with a relief hole, so that by turning the plug to one side direct communication is made from the cylinder to atmosphere. When the cock is turned in the opposite direction, the opening to the cylinder is entirely closed, and when half-way between these two positions a clear way is left to the indicator. The convenience of this relief will be appreciated when it is necessary to bar the engine round and to ease the compression.

In the older type of engines the indicator plug is usually on the top of the cylinder, all valves being either underneath or at the side, but in engines of later design the air valve is on top ;

consequently the indicator plug has to be placed at the side. The author has known cases where no provision has been made for the reception of an indicator, and it has been necessary to drill through a valve cover or other convenient place into the combustion chamber for its attachment.

Having fitted the indicator on to the cock, it is then necessary to decide as to how the reciprocating motion of the engine piston is to be communicated to the indicator drum. This is usually effected by a system of rods coupled to the piston, or by an attachment to the end of the engine crank-shaft. With the former method a standard A (see Fig. 7) must be erected, and this presents the first difficulty. If any provision has been made for the standard the thread will often be found to vary. In cases where indicator gear has not been considered at all in the design of the engine it becomes necessary to remove the cylinder lubricator and screw the standard into its place. This, of course, means another inconvenience, as lubrication must then be by hand, an obviously unsatisfactory method. Upon the standard is clamped a rod B, parallel to the longitudinal axis of the cylinder, upon which is clamped a short rod C at right

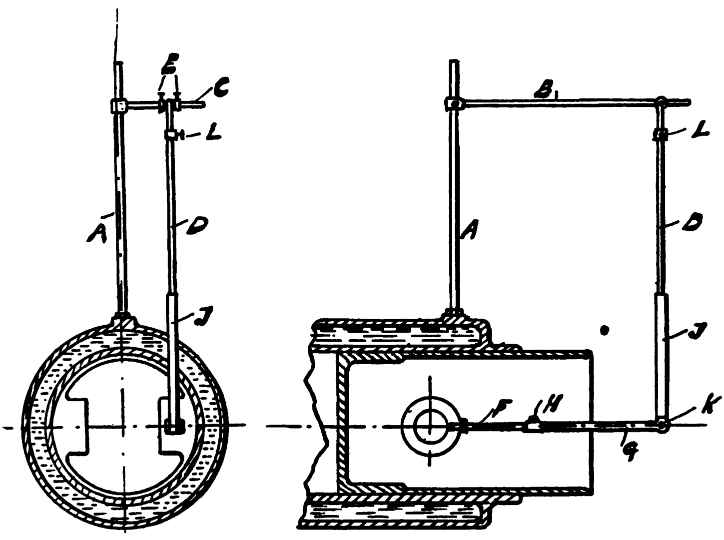


Fig. 7.—*Attachment of Indicator Gear to Piston.*

angles, from which the pendulum rod D is hung. This pendulum is free to swing longitudinally on C, but is prevented from moving laterally by the two clamping collars E. A rigid rod F is then fitted to the piston, either by removing one of the set-screws in the gudgeon pin or by screwing it into a lug specially cast in the piston. The other end of the rod F slides inside the hollow rod G, and is clamped in position by the nut H. To the other end of the rod G, a hollow sleeve J is fitted by means of a knuckle joint K, and the rod D slides in the sleeve J. The cord to the indicator is taken from the adjustable collar L.

To set this gear, the piston must be at the centre of its stroke, and the rods D and J both vertical. The collar L can be moved up or down to give the correct amount of travel to the indicator drum, and then clamped in position. The connection between the gear and the indicator should be by unstretchable cord, preferably with a flexible wire centre. The loose end of the short length of cord which is wound round the indicator drum terminates with a hook, which is attached to a loop on the cord connected to the gear, so that the indicator may be uncoupled occasionally during an indication. Some means of adjustment should be provided for lengthening or shortening the cord as desired, and a special spring clip is sometimes used for this purpose, which acts as a kind of slip-knot.

The other method of transmitting the reciprocating motion to the indicator, is by taking a connection from the end of the engine crank-shaft. This is generally done by using the Graham beam, which is small, made of aluminium, and is therefore easily portable. It consists of main body A

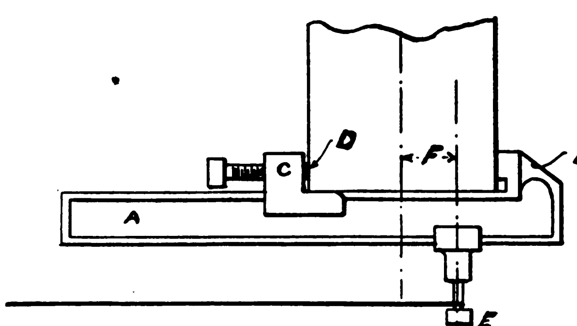


Fig. 8.

Connection of Indicator to Crank-shaft.

with fixed jaw B (see Fig. 8), carrying a kind of movable head-stock C, which is run along the body until it nearly touches the crank-shaft and is then fixed, the final adjustment being made by screwing up set-screw D, so that the beam is firmly clamped upon the shaft. Upon the opposite side of the beam, another sliding part E is fitted, and clamped in position when the dimension F is just a shade less than half the travel of the indicator drum. To set this beam the engine is barred round until the crank is on its out centre and is horizontal, as found with a spirit level. The set-screw E is then clamped in position at its correct distance, in a direction away from the cylinder of the engine. The connection between the beam and the indicator is obtained by taking an unstretchable cord from the former in a direction parallel to a line drawn through the longitudinal axis of the cylinder over a small pulley at the same height from the ground as the centre of the crank-shaft, and from this pulley the cord may be taken at any angle to the indicator. The small pulley may be screwed into any convenient wall or partition or a temporary wooden post may be set up for it, care being taken to get the cord from the beam to the pulley parallel to the centre line of the engine, as mentioned above, and the outstroke of the crank coincident with the outstroke of the indicator drum. Where a Graham beam cannot be used, owing to the crank-shaft being cut off close to a bearing or gear wheel box, the same result can be obtained by drilling and tapping a small hole in the end of the shaft, and inserting a pin from which to run the cord, taking care that the position of this pin is set the same as pin E would have been, had the beam been used, as shown in Fig. 8.

This method of connecting the indicator to the crank-shaft is not to be advised as giving absolutely accurate results, as the motion of the crank does not tally with the motion of the piston throughout the whole stroke. The inmost position of the piston is coincident with the inmost position of the crank, the two out positions also agree, but if the centre of the piston travel be measured, it will be found that the crank is lagging behind, and has not yet reached its central position. The effect of this will be to cause a slight inaccuracy in the centre of the diagrams taken with the cord run from the engine crank-shaft. This can easily be proved by setting out on paper a crank of a given

length, and with connecting rod of say five times the length of crank, as is usual in gas engine practice, marking off the position of the piston pin at the in centre, mid position, and out centre, and comparing with the position of the crank pin at each of these positions.

As regards the actual taking of the diagrams, having placed the paper round the drum of the indicator, the indicator cock is opened, which causes the pencil mechanism to rise and fall in accordance with the prevailing pressures inside the cylinder. The reducing gear being connected to the drum, registers such pressures in relation to the piston movement.

To determine the indicated horse-power of an ordinary single cylinder gas engine, four factors are necessary:—The mean pressure developed, the length of stroke, the diameter of cylinder, and number of explosions per minute.

The mean pressure is found as in steam engine practice by dividing the diagram into tenths and measuring the mean height. The stroke is measured in feet, and the area taken is that of the sectional area of the cylinder measured in square inches.

When there are a number of indicator diagrams to be worked out from the same engine, and it is necessary to compute the power from each card separately, it is advisable to employ the horse-power constant for that particular size of engine. The variable quantities which affect the power developed are the mean pressure and the number of explosions taken. The rest of the formula remains constant, so that this latter portion can be reduced to one figure, and when multiplied by the product of the mean pressure and the number of explosions, will give the indicated horse-power. Thus the constant is $\frac{L \times A}{33{,}000}$

The formula then resolves itself into I.H.P. = Constant × P × N.

The number of explosions is counted either by observing the number of times the gas valve is opened in a given time, or by listening at the end of the exhaust pipe, which latter method is to be preferred for two reasons, viz., first, because occasionally a charge is drawn in and not fired; second, in some engine rooms the noise and clatter are so great that attention to the counting is very apt to be diverted.

The formula given for finding the indicated horse-power does not make any allowance for the fluid friction of the gas, and in

order to do this the " mean effective pressure " is used instead of the " mean pressure." This becomes an important factor in cases where the engine has been fixed in such a manner that the pipes do not admit of the free admission and expulsion of the charge.

In order to ascertain what the amount of the fluid friction really is, it is necessary to take light spring indicator diagrams from the engine, and these diagrams give a magnified view of the bottom lines of the card. Two combinations of lines are discernable, the one set being obtained on power strokes, and the other on cut-out strokes ; the former are shown in full lines, and the latter in dotted lines in Fig. 9. Taking these two combinations on one card is rather confusing, and so for the sake of clearness, it is better to use a separate card for each set of lines.

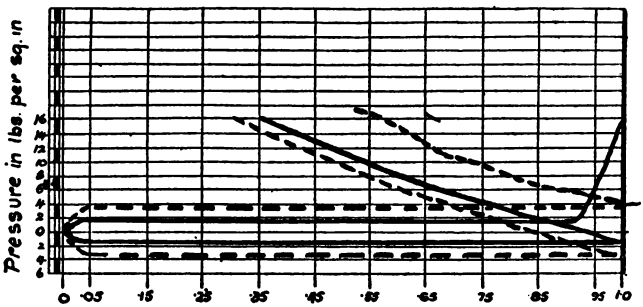


Fig. 9.—*Fluid Friction.*

The diagram from a power stroke is obtained by holding the governor in position, so that the engine takes a charge every cycle, while the indicator pencil is touching the paper. Such a diagram from an engine in fairly good condition will be something like Fig. 10. The line from A to B shows part of the exhaust line, B to C the suction line, and from C to D a portion of the compression line; X Y is the atmospheric line. To take any measurements from this card, it is necessary to divide it into tenths, as explained when dealing with mean pressure. On measuring the vertical distances between the dots, in terms of the scale of the spring used, and averaging, the fluid resistance in lbs. per square inch is obtained.

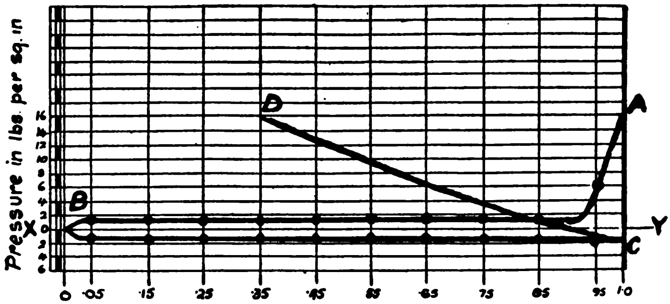


Fig. 10.—*Power Stroke.*

The cut-out card is obtained while the engine is taking a charge which is not fired. With the ordinary cut-out stroke as effected by the governing mechanism of the engine, air only is drawn into the cylinder, without gas, and is compressed, expands again, and is discharged through the exhaust valve. It is necessary to hold the governor trigger back to prevent the possibility of the gas valve being opened, while the indicator pencil is in contact with the paper.

In the diagram of a cut-out stroke as shown in Fig. 11, the expansion line is from A to B, exhaust from B to C, C to D the suction, and the compression from D to E, and atmospheric line X Y. The resistances on this card are measured as in the case of the light spring power card.

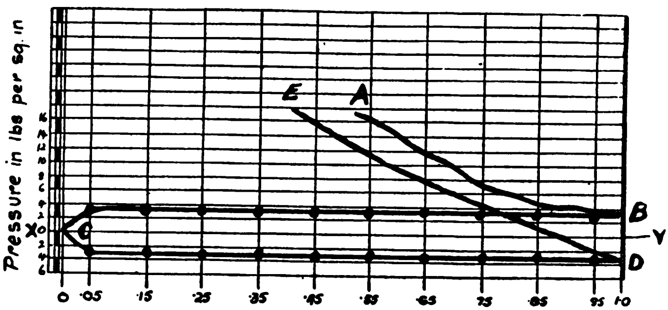


Fig. 11.—*Cut-out Stroke.*

There is thus fluid resistance on every power stroke, and again on every cut-out stroke. This means loss of power, as these resistances are negative in their action.

Another item which should be taken into account and which also is obtained from the indicator cards, is shown on air cycles when a charge of air only is drawn in and expelled again. This figure may be either positive or negative in its action, depending upon the working condition of the engine. It will be seen that when a charge of cold air is drawn into the hot cylinder, after compression, the air expands, due to its taking heat from the cylinder walls, and this is converted into useful work on the out stroke of the piston, as shown in Fig. 12, which is a diagram taken with a medium spring, usually $\frac{1}{100}$. The lower line is the

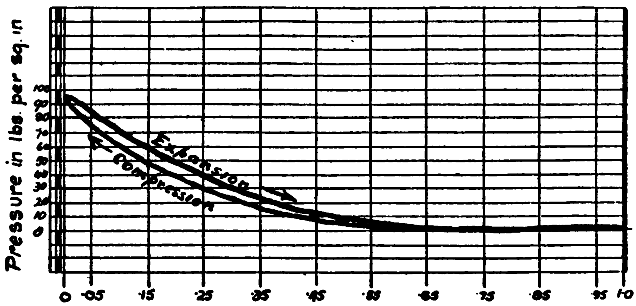


Fig. 12.—*Air Cycle.*

compression and the upper one the expansion, and if the area enclosed between these two lines be measured by dividing it into tenths as before, the extra work thus obtained on cut-out strokes can be measured in lbs. per square inch.

When an engine has been at work for some time, and the piston and valves become leaky, it is found that instead of getting useful work on cut-out strokes, a direct loss is obtained, as shown in Fig. 13, from which it will be seen that the expansion line has dropped below the compression; and so by measuring this area as before, the loss is found in lbs. per square inch.

To return to the original formula for indicated horsepower, it will be readily seen how these resistances alter

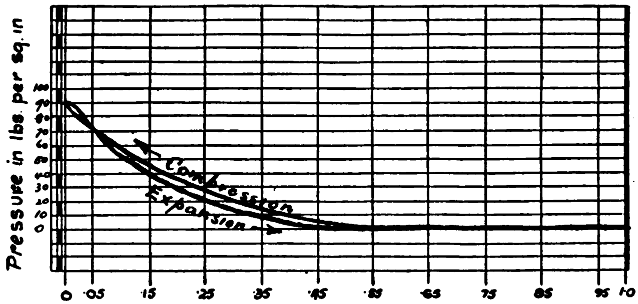


Fig. 13.—*Leaky Piston and Valves.*

the final result, the difference being that the mean pressure is now altered to the mean effective pressure. To calculate this latter, the number of explosions per minute should be included with it, and they will therefore be left out of the revised formula for indicated horse-power. Thus—

Mean effective pressure =

$$(B \times N) + (E \times M) - (C \times M) + (D \times N).$$

Where B = mean positive pressure of ordinary average power cards; C = mean negative pressure on cut-out cycles, as Fig. 15; D = mean negative pressure on power cycles, as Fig. 14; E = mean positive pressure of compression on cut-out cycles, as Fig. 12; N = number of fires per minute; M = number of misses per minute.

In engines with leaky pistons and valves, E becomes negative, and so the formula reads :—Mean effective pressure =

$$(B \times N) - \Big((E \times M) \times (C \times M) \times (D + N) \Big).$$

Then the revised formula for indicated horse-power becomes

$$\text{I.H.P.} = \frac{\text{Mean effective pressure} \times L \times A}{33{,}000}$$

It will be worth while to spend a little time in studying some of the variations of the cards and to explain their causes. In doing this, the power indicator diagrams and the air indicator diagrams will be considered separately.

The spring used for taking power indicator diagrams is usually $\frac{1}{200}$ inch, unless the engine is of the latest high compression type, and then it will be found necessary to use a stronger spring, such as $\frac{1}{300}$ inch or $\frac{1}{350}$ inch.

From this diagram the mean pressure is measured, while the corrections for fluid resistances are taken from the light spring cards, as explained previously. The shape and position of the lines show the condition in which the engine is working, whether well, badly, or indifferently.

Fig. 14 shows a specimen card taken from an engine in fairly good condition. The vertical distance from A to the atmospheric line, when measured in terms of the scale of the spring used,

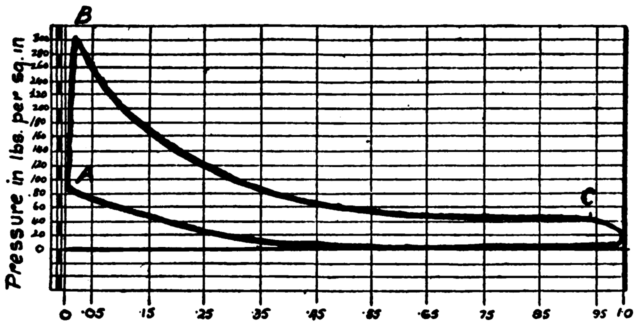


Fig. 14.—*Model Card.*

gives the highest or terminal compression pressure obtained, while the vertical distance from B to atmospheric line gives the maximum explosion pressure, and at C, which is the point of the opening of the exhaust valve, the distance to atmospheric line gives the pressures in the cylinder at the time of exhaust. If Fig. 14 be regarded as a correct card, it is easy to compare other cards for faulty working. The most important of the faults shown by the power diagram are:—Pre-ignitions, early firing, late firing, and weak mixtures.

Fig. 15 shows a pre-ignition occurring, and it will be seen that the point of firing, instead of starting from the end of the compression stroke, starts before compression has finished, and the explosion pressures fly up to a much higher pressure than normally. As the piston is travelling inwards at the moment of pre-ignition and has not completed its stroke, a sudden reversal of pressures is experienced, thereby throwing great strain on the crank, &c., because the weight of the flywheel is causing the engine to rotate in one direction, and these sudden stresses come directly opposite. Although the highest explosion

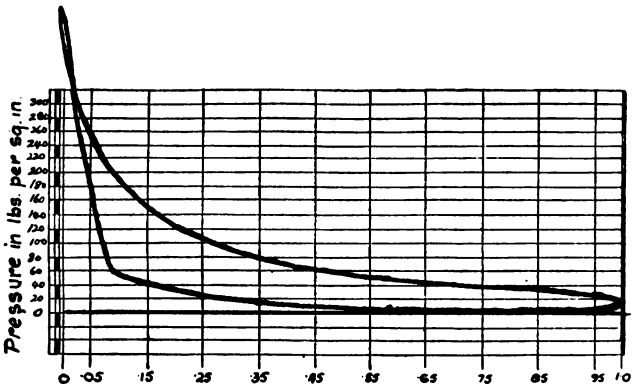


Fig. 15.—*Pre-ignition.*

pressures reached under a pre-ignition are higher than the normal explosion pressure, the mean pressure is lower than usual, as the card does not have the " body " in it as compared with Fig. 14.

Pre-ignitions are most frequently due to either particles of dirt getting incandescent and firing the gases before the correct time; lubricating oil getting past the rings and carbonising on the back of the piston, and becoming incandescent; projecting corners of the engine-casting in the path of the hot gases becoming red hot; or to long and narrow ports and other crevices in which flame lingers from the previous explosion and which do not get a scavenge of air.

Early firing is a trouble distinct in itself. Fig. 16 shows early firing occurring, and it will be noticed that the explosion takes place at the correct time, viz., the end of the compression stroke, and from this point the line rises practically vertical to a higher point than usual. This throws a shock on the crankshaft, and also causes the power developed to be lessened, but the effects are not very serious, and can be remedied by altering the timing of the ignition so that the point of explosion is slightly retarded.

If the ignition be set back too far, late firing occurs, with the result as shown in Fig. 17. The usual apex of the card will be found to be greatly reduced or entirely missing, and instead of a " kick up " at the end of the compression stroke, the line

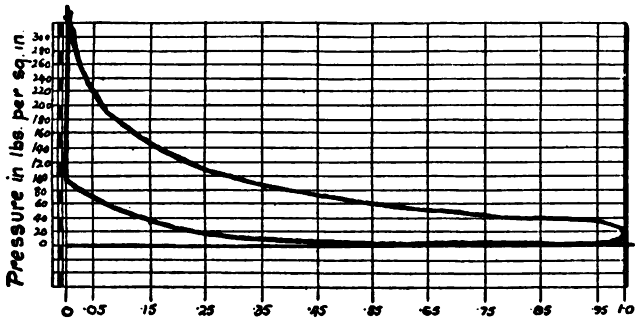


Fig. 16.—*Early Firing.*

retraces itself for a certain distance as the piston goes out again, and when ignition does eventually occur it is but a half-hearted affair and the power is greatly diminished.

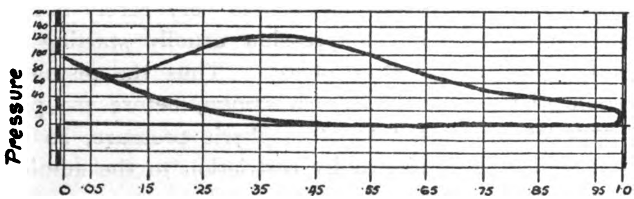


Fig. 17.—*Late Firing.*

Another similar card to the above is shown in Fig. 18, taken when a weak mixture was being supplied to the cylinder, the distinction between these cards being that in the latter case the point of ignition comes at its correct place. Weak mixtures, of course, diminish the output of work from the engine. The obvious remedy for weak mixtures is to regulate the supply of air or gas, as the case may be, and the rule for this is to keep the ingredient which is under the lesser pressure constant, and make all adjustments on the other.

Air indicator diagrams are obtained with the use of the light springs previously referred to, when the question of the calculation of fluid resistances was being dealt with.

Taking the suction line first, in Fig. 11, it will be seen that the suction stroke should commence from the atmospheric line, and as the piston moves outwards, the pressures in the cylinder

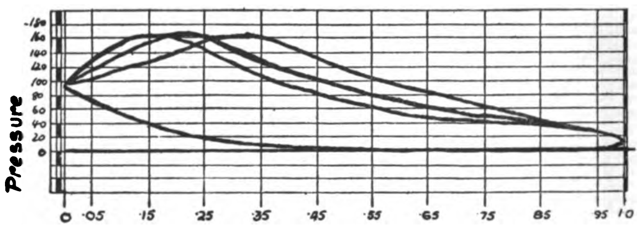


Fig. 18.—*Weak Mixture.*

drop a little below atmosphere, thereby inducing the fresh charge into the cylinder; and this line terminates at D, the out stroke of the piston. Any obstruction to the free admission of the mixture to the cylinder is shown by this line dropping lower than usual. The compression curve starts from D, and rises in the direction of E. An ideal compression would start from atmospheric pressure, but this is very rarely obtained in gas engine practice, the compression usually starting from a point a few lbs. below atmosphere. Thus the piston has to cover some distance on its return stroke, before the pressures in the cylinder are raised to atmospheric pressure, so a direct loss to compression is shown by restriction to the admission of the charge.

The expansion curve is shown by the line from A to B, which latter point should be close to the atmospheric line, so that the exhaust line from B back to C keeps as near as possible to the atmospheric line. The position of this exhaust line is of great importance with regard to the good working of an engine. Under ideal conditions this line should coincide with the atmospheric line, but it frequently happens that although it may be fairly close at the beginning of the exhaust stroke, as it gets towards the end, a distinct "kick up" occurs, which indicates a piling up of pressures due to some restriction to the free expulsion of the charge. Occasionally, however, it is found that this line actully drops below the atmospheric line at a portion of its length, and this is due to the scavenging of the cylinder caused by the column of exhaust gases, rapidly and freely moving away through the exhaust pipe, and thereby inducing all the gases out of the cylinder and tending to cause a vacuum. This effect is usually obtained by a long length of exhaust pipe of

ample size and without restrictions. As this induced scavenging, whenever it occurs, is beneficial to the engine, some makers adopted the plan of giving the exhaust gases a good run before escaping to the open air, by arranging a series of pipes, as shown in Fig. 19, of such a diameter that the restriction caused by the bends was balanced. Although engines thus fitted are to be found now, it is doubtful whether the device was worth the extra expense, and whether in a good many cases scavenging did occur at all.

If the exhaust line does not get down to atmosphere at the end of the stroke, a part of the next suction stroke is spoilt by having to reduce the pressures within the cylinder to atmospheric pressure before any entry of the fresh mixture will commence.

If the light spring card of a cut-out stroke be compared with the light spring power card, it will be found that the resistances are not the same, although both diagrams are from the same engine. If Fig. 11 be taken as a specimen of a light spring air card, and Fig. 10 as the light spring power card, the differences are easily discernible. In the former there is no explosion occurring, therefore the gases do not have the aid of the explosion to assist them getting away as in the latter. There is also a greater resistance to the admission line in the case of the air card ; this is explained by the fact that on air strokes no gas is admitted, therefore the cylinder has to be filled with air alone, and as the gas valve is not open, the whole of the charge has to come in through the air pipe. This restriction is much more marked in the case of engines running on suction gas, where the proportions of gas and air are about equal, for if the gas be shut off, half the admission area is closed and a much greater inductive effort is required to cause sufficient air to fill the cylinder through the air pipe.

It should be noted that the position, size and design of exhaust silencers, have a very important bearing upon the economical working of an engine. Gas engines, being rather noisy machines, by reason of the sound of the explosion being transmitted from the cylinder through the exhaust pipe to the atmosphere, it is necessary to employ some method of deadening the sound without putting undue restriction on the exhaust. The majority of makers provide a simple cast iron box for this purpose, with the inlet at the side and the outlet on top, and this

is usually found to do all that is necessary. The position in which this box is fitted is, however, a very important consideration. Its best position is at the far end of the exhaust pipe. If it be placed close up to the engine, the indicator diagrams show that the gases, leaving the cylinder at high velocity and upon entering the silencer, suddenly expand and lose much of their speed, and so require a strong push to make them travel through the remaining portion of the pipe. The indicator diagrams confirm this by the exhaust line, starting from somewhere about atmospheric pressure, rising suddenly towards the middle, and falling slightly towards the end of the stroke.

Some makers prefer to adopt a form of exhaust silencer, which consists of putting ballast in a box, and bringing the inlet of the exhaust pipe to stand up through it, as in Fig. 20, the ballast being supported upon an iron grid. The gases then pass through the ballast and away through the outlet. The ordinary type of silencer is to be preferred to this, but it sometimes happens that one is prepared to yield a little on the score of economy to obtain a more silent running engine. It should be added that unless the apparatus be cleaned out frequently, the ballast becomes solidified, preventing the free passage of the exhaust gases.

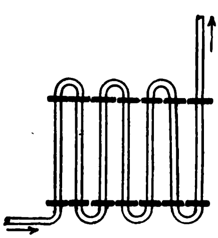


Fig. 19.
Exhaust Pipes.

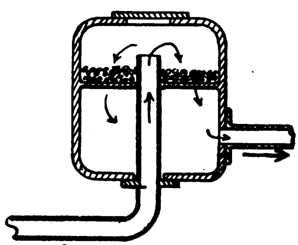


Fig. 20.
Silencer.

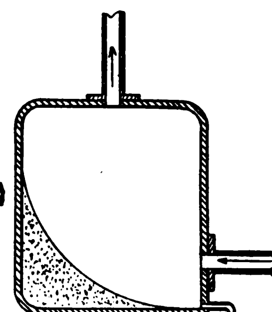


Fig. 21.
Exhaust Box.

The exhaust may also be effectively silenced by the injection of water into the exhaust pipe, a method which has been found to be effective when others have failed. It has its disadvantages however. Rapid deterioration of the exhaust pipe takes place, due to chemical action. The pipe and silencer become corro'ed at the corners and angles where the moisture

impinges upon the metal, but it has been found possible to lengthen the life of the box by laying concrete in the corner opposite the inlet of the gases, as shown in Fig. 21, thereby protecting the metal at this point.

Another type of indicator diagram is that known as the explosion card, produced by the Mathot recorder, an instrument consisting of an additional drum fitted to the indicator, and not connected to the reciprocating gear attached to the engine, but operated by clockwork. The pencil mechanism is the same as for the ordinary indicator. The diagrams indicate a succession of explosion and cut-out strokes, as shown by Fig. 22; the fires are denoted by A and the cut-outs by B. This instrument obviates the necessity of mental counting to ascertain the number of explosions per minute; all that is required is to mark off the number of cycles that occur in a minute and count the number of fires contained in the distance. It is also useful in demonstrating the working condition of the engine. If the engine is

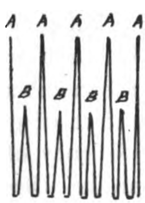


Fig. 22.

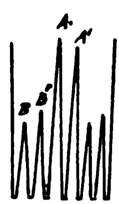


Fig. 23.

Diagrams from Mathot Recorder.

in perfect order the heights of all the explosion records will be fairly constant, a condition which, however, seldom obtains, especially with an engine running on producer gas, when every small change in the load has its effect on the gas generated. Another irregularity which often occurs is shown by Fig. 23. Comparing cut-out B with the second cut-out B^1, it will be noticed that the latter is slightly higher than the former. This is due to the cylinder being cooler at the second cut-out, having just received a scavenge of air only; the temperature therefore being lower, more air enters. The explosions vary in a somewhat similar manner. The first fire (A) after a cut-out is frequently higher than the second (A^1), owing to varying pro-

portions of gas and air entering the cooler cylinder after a cut-out stroke, which is not the case after another explosion.

Determination of Fuel Consumption.—With engines running on producer gas the record of fuel used is obtained by weighing each bucketful of coal or coke supplied to the producer in a given time. It is then necessary to reduce to a standard basis the figure representing the fuel consumed, by taking into account the power developed so as to bring the result to lbs. of coal per B.H.P. hour. A good average figure for a well-kept engine running under fairly favourable conditions is $1\frac{1}{4}$ lb. of anthracite per B.H.P. hour, but this must not be taken as a standard. As working conditions vary so much it is not right to conclude that an engine's fuel consumption is excessive because it is greater than a standard figure.

With town gas, the result is recorded in cubic feet per B.H.P. hour, and is merely a matter of reading the gas meter and comparing with the power developed in a certain period. As a check, it is advisable to stand by the meter and count the number of explosions which occur while the index finger of the meter records, say, 10 cubic feet of gas; then, working on the indicated horse-power formula, to calculate the number of cubic feet of gas per I.H.P. by substituting cubic feet of gas for explosions. After allowing for the mechanical efficiency of the engine (ratio of I.H.P. and B.H.P.), the result can be checked against the figures obtained from the brake horse-power direct.

If particularly accurate results are required, it becomes necessary to reduce the gas meter readings to a standard temperature of 32° F., and a standard pressure of 14·7 lbs. per square inch, by the use of the following combined formulæ:—

$X = V \times \frac{493}{T + 461} \times \left(\cdot 033\ B + \cdot 0024\ J\right)$. Where V = volume of gas measured by meter in cubic feet; T = temperature of gas entering meter; B = reading of barometer in inches of mercury; J = pressure of gas in mains in inches of water.

Water Circulation.—The correct temperature of the cylinder jacket has much to do with the efficient working of an engine; if the temperature be too high the admission of the mixture is restricted, and if too low, a considerable proportion of the heat value of the explosion is lost on the cold cylinder walls; moreover, it is not possible to obtain any benefit from the expansion

of the air on cut-out strokes. A good average working temperature for the water jacket is between 140° and 150° Fah., but if the engine be one of the latest high compression type, the temperature may be advantageously dropped to 120° Fah. The regulation of the temperature of the circulation water with the ordinary cooling tank installation is effected by adjusting the valve on the cold water inlet to the engine.

The circulation for small to medium-sized engines is usually provided for by one or more tanks, connecting the bottom of the cylinder jacket with the bottom of the tank, and the top of the latter with the top of the jacket. The size and number of these tanks depend upon the power of the engine and the number of its working hours. The quantity of water used should not be less than 30 gallons per B.H.P. hour. Where two or more tanks are placed in series it is frequently found that the connecting pipe between them is no larger than that which connects the tanks to the engine jacket; this is too small, as the pipe being horizontal, free circulation, which is so necessary, cannot take place.

As to the position of the tanks it should be remembered that the bottom of them must not be lower than the top of the cylinder. It is usual to couple all tanks together at the top only, and each tank should have a dip piece fitted inside, to facilitate effective circulation as shown in Fig. 24, and so prevent any short-circuiting of the hot water straight across the top of one tank to the next. The cold-water pipe from the tank to the engine should be provided with a stop-cock in all cases, fitted close to the tank, so that the cylinder jacket may be drained in cold weather to guard against danger of fracturing the jacket through frost.

For engines above 50 horse-power, it is advisable to provide a small centrifugal pump, driven from the crank-shaft, and arranged on a by-pass on the cold-water pipe, to assist the circulation. Such pumps are not expensive, take up little room, and do not require much attention.

Trouble with circulation is sometimes caused by failing to keep the jacket clean. Deposit can be readily removed by filling overnight with a solution of water and common washing soda, in the proportion of 1 lb. of soda to 100 gallons of water; if this be allowed to remain all night, on draining off in the morning

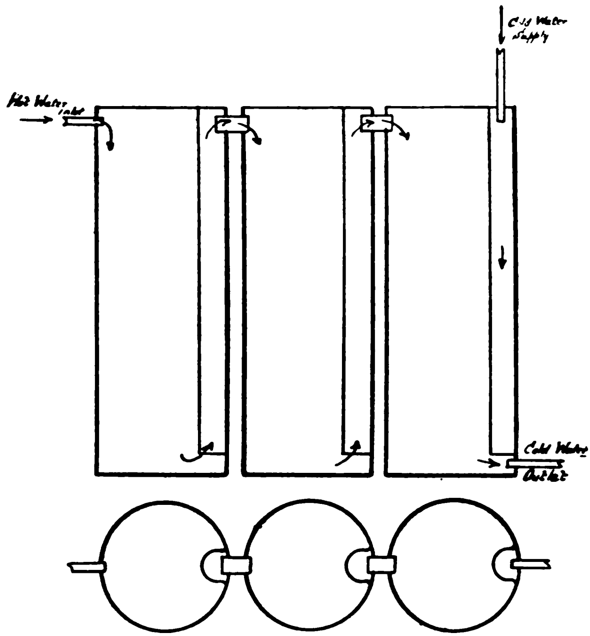


Fig. 24.—*Cooling-water Tanks.*

and well brushing the jacket the deposit will easily come away. The frequency of cleaning will of course depend upon the hardness of the water used and the working hours of the engine, but about once a month will usually be found sufficient.

Preparation of Report.—If the engine is simply being inspected or indicated to ascertain its working condition, it will not be necessary to refer to the sizes of bearings, &c., but where a complete test is desired it is advisable to draw up the results in tabular form as indicated in the schedule given earlier in the paper.

Many tests are carried out at the request of the power user, who may not be very conversant with engineering matters. It is therefore necessary to prepare the report so that it may be intelligible to the man who is not an engineer. Taking the very ordinary case of a power user who has a gas engine which is giving trouble; the attendant will probably have stated his views as to why the engine runs badly, but finds the task of

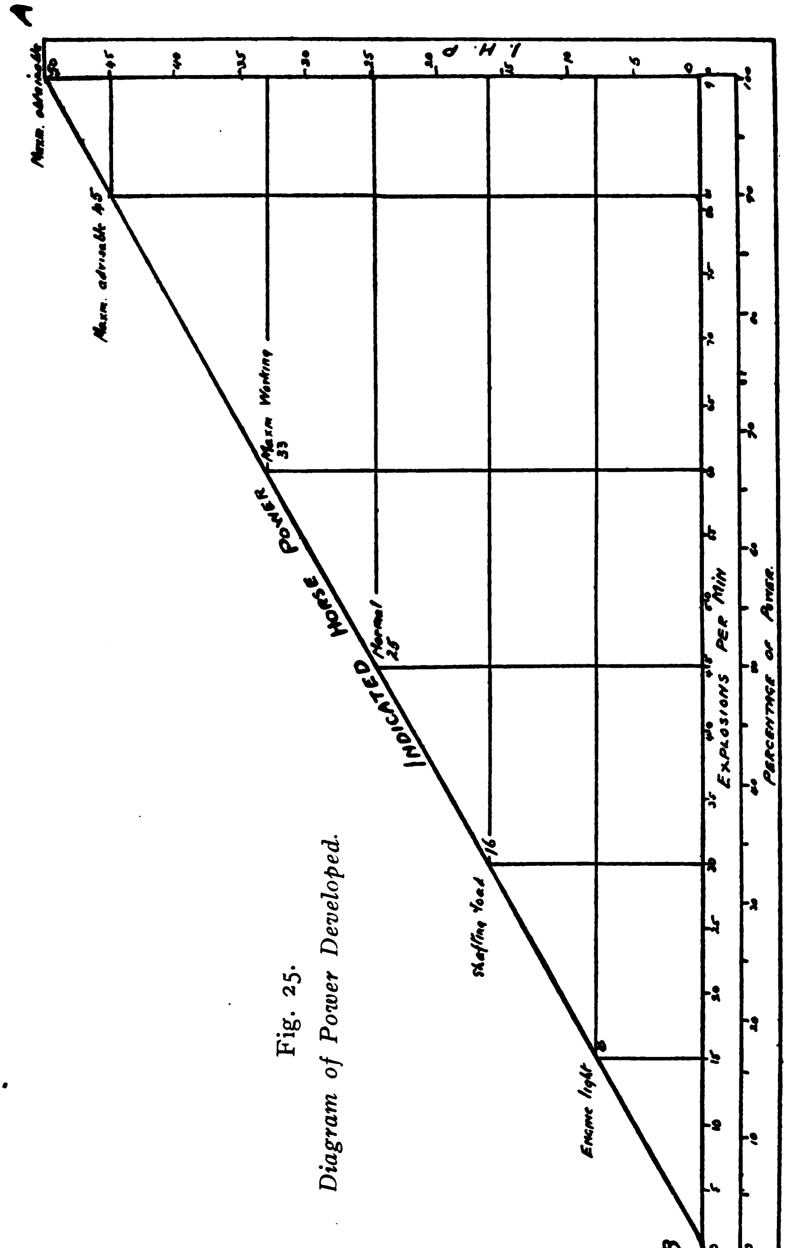


Fig. 25.
Diagram of Power Developed.

setting it right a little beyond him ; and an expert is called in to examine and specify a remedy, and it has been found that if a tracing of some of the diagrams obtained be submitted with the report it enables the engine's faults to be clearly delineated intelligibly to the power user.

A factory owner desiring to lay down another machine will wish to know whether his engine will carry the additional load. The test having been conducted in such a manner that figures are available for the power absorbed with the engine running light, with the shafting load only, with normal working load, and with maximum load obtainable, a chart may be plotted, preferably on squared paper, to accompany the report, giving details of the power developed during the different stages of load, as shown in Fig 25. Here the vertical scale represents I.H.P. developed, and the horizonal scale, explosions per minute (the mean pressure being assumed constant throughout the test). If the maximum power obtainable when the engine fires every cycle be marked on the vertical scale, say at A, and a line be drawn from that point back to B, the power developed at any number of explosions per minute can be readily ascertained by raising a perpendicular to the line A B and noting the length of this perpendicular.

Thus in an engine running at 180 revolutions per minute, and of 50 I.H.P., the maximum power the engine could develop would be when the explosions occurred at 90 per minute. Possibly the normal working load would require 45 explosions, giving 25 I.H.P. as the normal power developed, and supposing the maximum working load requires 60 explosions, this would correspond with about 33 I.H.P. A glance then shows that the engine has in reserve a third of its power, and amounting to 17 I.H.P. After deducting 10 per cent. of the full power of the engine as a margin of safety, 12 I.H.P. remains, which may safely be regarded as available for extra work. If a perpendicular be dropped from the line A B at the point denoting 45 I.H.P., the number of explosions which must not be exceeded will be read off at the base as 81.

DISCUSSION ON THE TESTING OF GAS ENGINES.

THE CHAIRMAN congratulated the author on the excellent paper which he had prepared in response to the invitation to members under the age of twenty-one to contribute in this way to the Institution's Transactions. He trusted that others would now come forward, so that the junior members would feel that their interests were being fully considered in the programme of work.

MR. W. A. TOOKEY (Member) said that he cordially agreed with the Chairman's remarks with reference to the presentation of papers by the younger members of the Institution. Mr. Whalley had set a good example, and he hoped that his paper would be the first of a series which the Institution would have from its younger members. He had the pleasure of proposing a vote of thanks to the author for the evident labour he had bestowed upon the preparation of the paper. It covered a wide range of subjects, and gave one some idea as to the very many essential details to which attention must be directed by those undertaking to check the performances of a gas engine in industrial service. He thought that a better title for the paper would have been "Practical Notes on the Commercial Testing of Gas Engines," as there were many points not alluded to by the author which were matters for consideration when it was desired to obtain data for the determination of the performances of such engines upon a scientific basis.

He noticed that in more than one place in the paper there were comments upon the fact that in some engine-rooms considerable noise and clatter occurred. He hoped the author would agree with him that such noise and clatter were not due to the gas engine, but rather to the machinery driven by them. There were many gas engines working to-day which were quite as silent in operation as the best examples of steam engines.

With reference to the indicator diagrams reproduced throughout the paper, the author no doubt meant these to be merely diagrammatic, as some of the curves shown at the termination of the exhaust stroke and commencement of the induction stroke (particularly the former) were never realised in practice.

With regard to the remarks upon the relative mean pressures of expansion and compression curves on "cut out" cycles, he (Mr. Tookey) had had a rather curious experience in this connection. Carrying out an inspection on behalf of a client, the indicator diagrams showed that the ignition of the charges was taking place too early, and he recommended that an alteration should be effected to prevent this. The owner of the engine, however, would not consent, because, he said, it had been previously pointed out to him that the charge was firing early, and on one occasion he had accepted the advice and caused ignition to be delayed, with the result that a considerable increase manifested itself in the weekly gas consumption. This showed that it was commercially provident to waste a great deal of the heat of the explosion in warming up the water round the cylinder, and abstracting the heat again during the cut out stroke. At first sight it would seem that here was a step towards perpetual motion. The peculiar circumstances of this particular installation were that the engine was lightly loaded, the cut out cycles outnumbering the power cycles, so that any heat that could be abstracted from the cylinder walls, appeared as work on the diagrams, and, by reason of this, a lesser number of power strokes were called for. Another factor towards the result was that the water in circulation was restricted in small pipes and at the consequent higher cylinder temperatures the piston friction was much less than when the engine was running cold. Therefore, when by delayed ignition, the amount of heat abstracted by the jacket water was decreased, the friction of the piston increased, and so affected the gas consumption. This was quite an unusual state of affairs, but for that reason he thought the members would be the more interested and be able to appreciate the author's remarks.

With regard to Fig. 13, he hardly thought that the diagram proved conclusively the existence of leaks through pistons and valves. It appeared to him that the diagram in question illustrated rather the cooling effect of the cylinder walls, as it would be noticed that, at the highest point of the diagram, there was no rapid falling of pressure such as would occur if the gas were leaking past the piston, for it was at higher pressures that such leakages were most apparent.

The author spoke of a sudden "reversal" of pressures conse-

quent upon pre-ignition, but did he not mean to convey that there was a sudden "increase" of pressures which resulted in a reversal of strains to which the crank-shaft and fly-wheel key was subjected? Again, the author in the original copy of his paper, referred to the necessity of regulation of gas and air to obviate weak mixtures, "the rule being to keep the ingredient which is at the greater pressure constant, and make all adjustments on the other." The author probably intended to advise the constancy of adjustment for the ingredient at the "lesser" pressure, as, obviously, the tendency was for the engine to obtain its supplies through the least unrestricted sources, and it was therefore necessary to throttle down the ingredient which was at the greater pressure.

Another point the author did not seem to make sufficiently clear was that with regard to the removal of deposit within cylinder jackets. He advised that a weak mixture of soda and water should be placed within the cylinder jackets over night, and it would be found in the morning that the deposit would be loosened. The removal of deposit, however, was not such a simple matter as this. The speaker quite agreed that the use of soda in the circulating water lessened the probability of large amounts of scale being deposited, but the treatment suggested would in his opinion be inefficacious as regards removal of deposit, which was already formed.

Mr. Stanley Hughes (Member), as a colleague of the author, very cordially seconded the vote of thanks which had been proposed.

Mr. G. E. Lygo (Member) complimented the author on his very interesting and useful paper, and agreed that the engine should be fixed so that the belt should drive away from the engine to get the slack side of belt on the top, but pointed out that in some cases lack of space did not permit of this. Owing to the short belt drive it was sometimes deemed advisable to reverse the direction of the engine. Care should be taken that the driving belt was not too vertical, otherwise belt-slip would cause trouble. In checking valve settings the fly-wheel should be barred round in a forward direction, as there was a considerable amount of wear in the cam-shaft gearing of an engine which had been working for perhaps some years. He asked the author if he could give any particulars of results obtained from the Sellar's dynamometer, consisting of

a lever, on one end of which was a brake block running on small flanged wheels. This brake block was attached to a spring balance fixed on to the lever, the block was placed under the fly-wheel of the engine, and the load was applied by placing weights on the opposite long end of the lever. The power was then ascertained by the reading of the spring balance, to which a simple formula was applied.

MR. CECIL G. EVANS (Member) asked with reference to the water-cooled exhaust box what quantity of water was injected into the exhaust pipe; what the increase (if any) was in diameter of that exhaust pipe necessary to facilitate the escape of steam produced; what was the degree of temperature of exhaust gases, and whether diagrams could be shown indicating the effect of such water cooling. He referred to some experiments on a recently installed three-cylinder gas engine, with electric ignition, in which great difficulty was encountered through short circuiting, caused by a deposit of water on the ignition plugs. It was suggested that the water was due to condensation from the gases after explosion. Would the author state what his experience had been in such cases.

MR. ROBERT W. A. BREWER (Visitor) remarked that the author, in dealing with the particulars which had to be taken before a gas engine could be tested, as set forth in the beginning of the paper, had omitted one of the most important measurements, namely, that of the compression space. In order to obtain any really useful data from a gas engine trial, it was most essential that such measurements should be taken so that thermo-dynamic data could be obtained. This included the most important determinations to be made in a gas engine trial.

If accurate results had to be recorded, it was of course always necessary to have the measuring instruments calibrated, both before and after the test, so that no dispute could be raised with regard to the accuracy of the observations. Alluding to instruments for testing the brake horse power, Mr. Brewer exhibited a dynamometer made by Mr. W. G. Walker, which possessed many advantages, particularly when used on engines running at high speeds, because no heat was generated in the instrument. One of the difficulties in making a brake test was thus eliminated. Mr. Brewer also exhibited a large number of wall diagrams, which had been kindly lent by Mr. Dugald Clerk (Past-President).

FIGS. 7.

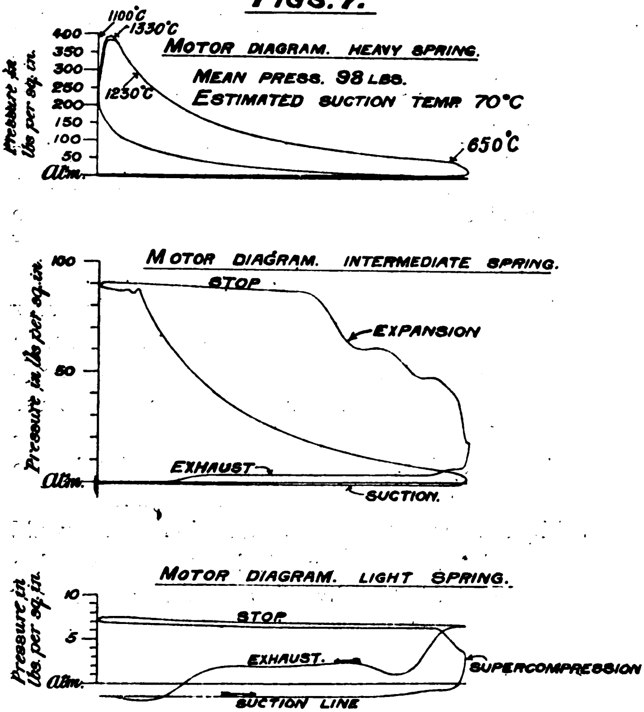


Fig. A.

Fig. B.

Fig. C.

Fig. 7 C was a diagram for a light spring card, and, neglecting super-compression which was there indicated, and examining the exhaust line, the fall of pressure in the exhaust pipe was denoted. It would be noticed that the drop occurred very rapidly, and that the pressure fell, again to rise, owing to some obstruction which probably existed in the exhaust pipe. Following the stroke further along, as the exhaust gas got away the pressure again dropped to below atmospheric, which was due to the inertia of the exhaust gases, passing out through the pipe. A study of this line would show where the exhaust was free and where it was choked, and this drop of pressure below the line, combined with a certain setting of the inlet valve, had a beneficial effect in scavenging, to a certain extent, the combustion space.

Dealing with the suction line, it was most essential that it should rise as nearly as possible to the atmospheric at the end of the stroke, as even a negative pressure of 1·5 lbs. per square

inch below the atmosphere would be sufficient to account for a loss of 10 per cent. in the efficiency of the engine. The position which this line occupied at the end of the stroke gave some indication of the freedom of the inlet passages, and the sufficiency of area of the inlet valves.

Mr. Brewer considered that Fig. 12, shown by the author, was open to considerable doubt, although it might be possible that the expansion line could come above the compression, owing to very much retarted ignition. In general practice such a state of affairs was not likely to occur.

Considering the interchange of heat which took place, in order to effect such a result during the compression stroke, a certain amount of heat passed away from the gases in course of compression, to the cylinder walls, which was again given up to the gases during the expansion stroke, but, unless the flame temperature was retained in the cylinder until a very late point in the working stroke, it was most unlikely that the amount of heat which was regained by the gases during the expansion stroke would be even equal to that which was taken up during the compression stroke. As an example of what really did occur, Fig. 2 below,

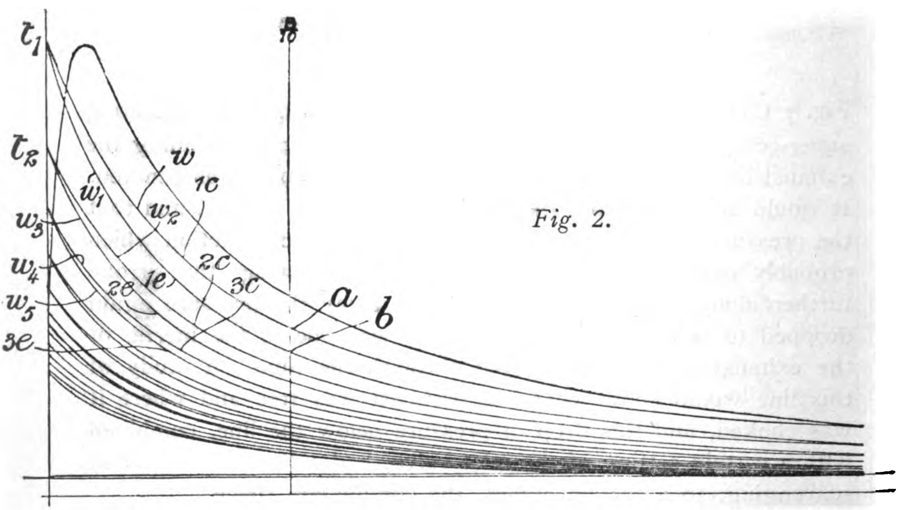


Fig. 2.

showing Mr. Dugald Clerk's cooling curves (Royal Society Proceedings, Vol. 77, page 501) clearly indicated the interchange

of heat during these two strokes. The method by which these curves were obtained by Mr. Clerk was as follows:—An engine was taken in which it was possible to throw the cams out of gear, and, after the normal speed had been attained, the cams were thrown out, all the valves remaining shut, and the mixture in the cylinder expanded and compressed until the engine slowed down to some extent. The momentum of the fly-wheel of course kept the engine running whilst the curves were taken. Although, after the first compression a temperature and pressure were reached practically equal to the initial temperature and pressure, the temperature fall was shown by the consequent curves, and it would be seen that during each period there was an interchange of heat, which was graphically represented, and that the drop in temperature increased most rapidly at the higher temperatures and less rapidly as the lower temperatures were reached. This method clearly indicated that the expansion curve would fall below the compression curve. If the difference between the theoretical and practical curves which were obtained in an indicator diagram, were considered, taking first the compression curve and plotting from the same origin the theoretical curve it would be found that the temperature and pressure actually reached would fall below the theoretical value, thus showing a heat loss to the walls of the cylinder. But in the expansion stroke it would be found that part of this heat returning towards the end of the expansion, the actual curve obtained came above the theoretical curve at a point about half-way along the out stroke.

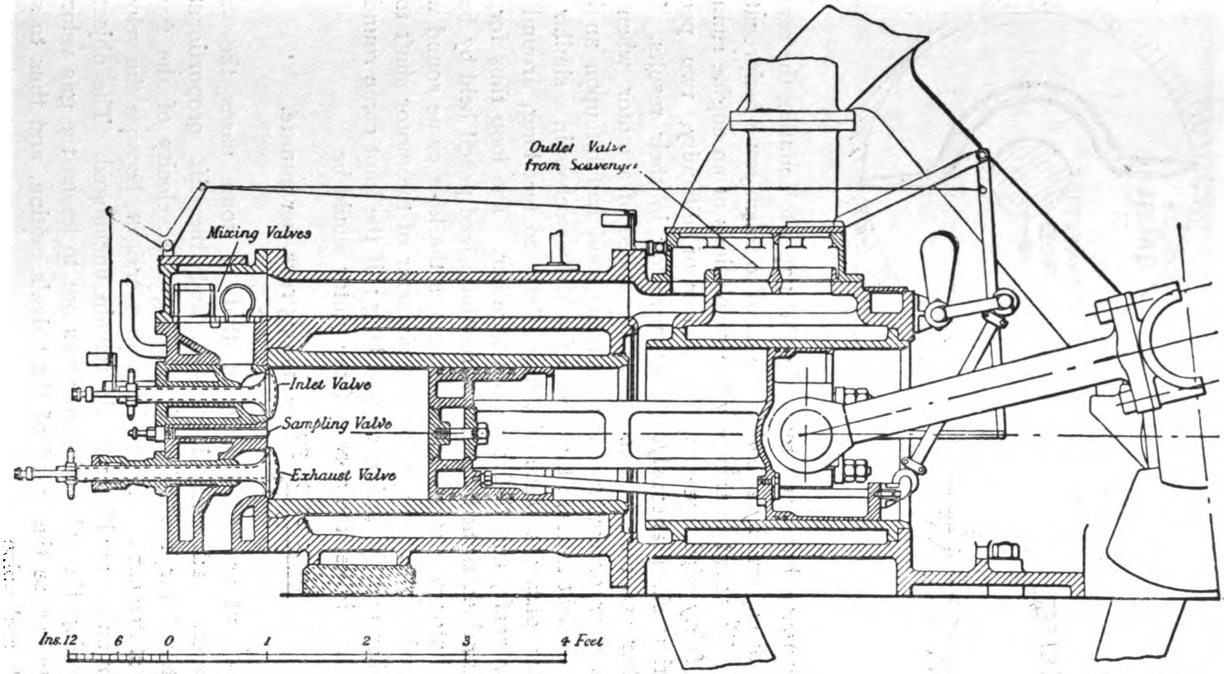
This fact disproved the after-burning theory to some extent, and the speaker thought it was quite sufficient to account for the difference in the theoretical and actual positions of the expansion curve upon the diagram.

With regard to pre-ignition, Fig. 15 of the illustrations, showed a pressure rising up very much above the normal, but it would often be found that this did not occur to such an extent as was there indicated, for the reason that when pre-ignition did occur the compression was not carried out to the full extent, and consequently, the firing pressure did not reach to so high a value as it did when a normal explosion took place. Naturally, owing to the piston continuing this inward stroke after the movement of firing the pressure of a pre-ignition was increased by compression to some extent, but, generally speaking, not to the extent

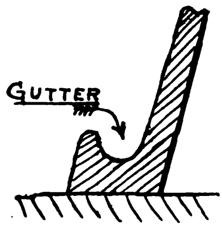
indicated in the diagram. The danger of pre-ignition really occurred in large engines more particularly, and, owing to the position of the crank, when the pressure rose more than to the actual pressure, as indicated in Fig. 15.

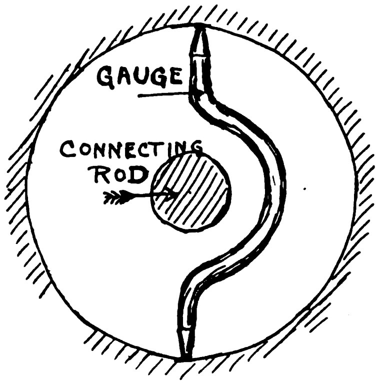
MR. W. H. STEVENS (Associate) asked whether the air resistance brake could be used say for 10 H.P. at as low an engine speed as 200 revolutions per minute, and whether varying the clearance between the blades and floors, &c., altered the result from the calibrated records which accompanied the instrument. Pre-ignition was a very serious trouble. Probably members had noticed the ideal shape of the compression space in the engine used by Prof. Burstall, in the experiments which he had conducted for the Institution of Mechanical Engineers. As would be seen from the illustration on page 405, which was reproduced from the report of the experiments, it was a simple cylinder bored throughout inside, leaving no places in which dirt or unburnt gases could repose.

MR. R. H. PARSONS (Member of Council) hoped that the excellent example set by the author would induce others of the younger members of the Institution to come forward with papers on work with which they were familiar. Mr. Whalley's paper was essentially practical, and the speaker would confine himself to practical points in discussing it. In the first place, as regards the trouble with oil from the engine making a mess and injuring the foundations, all makers of engines, pumps, &c., should be induced to cast a gutter round the bottom of the bed-plate, as shown in the sketch below, to catch any oil running down. This was a feature of much modern machinery, and was a very great improvement indeed. With the author's proposed method of measuring the diameter of the cylinder with two pieces of wood, Mr. Parsons entirely disagreed. It was very clumsy, and likely to be inaccurate. The ordinary "wire gauge" method was much simpler, and could be relied on to a thousandth of an inch. It consisted in taking a piece of quarter inch iron rod, slightly shorter than the diameter of the cylinder, filing the ends to a blunt cone, and fitting it to the cylinder. By hammering the sides of the rod, it could be lengthened until the exact fit was obtained. Moreover, by bending the centre of such a gauge into a bow, as shown in the sketch, it would clear the connecting rod, and be fitted as easily as if no rod were present (page 406).



Longitudinal Section of 16 inch by 24 inch Experimental Gas Engine. University of Birmingham.





Reference had been made in the paper to counting the revolutions of engines by allowing the hand to touch some reciprocating part. To count in this way the revolutions of an engine running at a fairly high speed was a matter of difficulty, two people counting simultaneously, rarely agreeing in their results. The speaker had once had to get at the speed of a motor when no tachometer or counter was available, and had hit upon an idea which might interest those who found themselves in a similar fix. He had passed a piece of string, about 20 feet long, around the motor shaft, and tied the ends together. The loop thus formed was strained tight by a cotton reel on a lead pencil held by hand. The motor was started, and the times the knot came round were counted. Then, supposing the diameter of the motor shaft to be 2 inches and the string 20 feet long; if the knot came round 30 times a minute, the speed of the motor would be

$$\frac{20 \times 12 \times 30}{2 \times 3\frac{1}{7}} = 1145 \cdot 5 \text{ revs. per minute.}$$

The author had mentioned that in some cases the valve diameters had been increased, and the lift proportionately shortened for the sake of reducing the velocity of the gases. This statement must have been an oversight, because the velocity under such conditions would remain unchanged. The object of increasing the valve diameter was not to lessen the gas velocity, but to reduce the speed of the valve's motion, and thus to save shock and noise.

CORRESPONDENCE ON THE TESTING OF GAS ENGINES.

Mr. H. T. Gould (Member) wrote:—I should like to thank Mr. Whalley for his most interesting paper. He has dealt with the subject in a very practical way, and the paper will be a useful addition to our Transactions.

With reference to the cord between the indicator and reducing gear this often gives trouble owing to stretching, and should therefore be as short as possible. The adjusting clip also is liable to give trouble at times, particularly in a fast running engine, and it is best, once the cord is adjusted, to "bind" the clip in such a manner that it cannot slip. I have also found it worth the trouble in a quick running engine to use a piece of strong elastic and fix one end on to any convenient stationary point close to the indicator, and the other to the moving cord in such a manner that when the drum of the indicator is stopped for putting on a cord, the "slack" of the cord is taken up by the elastic, so preventing the cord flapping about and getting caught and broken. This does away with the necessity of unhooking, and all strain or movement of the indicator is obviated. To put the indicator into action again it is only necessary to slip the paul out of the rack on the drum. The elastic should be practically parallel to the cord, so as not to influence the direct pull on the indicator.

With regard to the late firing cards, trouble in this direction is easily detected by the great heat of the exhaust pipes and silencer. The gases passing out of the cylinder in some cases are still burning, and naturally heat up the exhaust pipes. A regular attendant on a gas engine should at once notice when this occurs.

VISIT: LABORATORIES, &c., AT KINGS COLLEGE, LONDON.

The Eleventh Visit of the Twenty-seventh Session, at which the attendance was 56, took place on Saturday, 22nd February, 1908, at 3 p.m., to King's College, London, for an inspection of the Experimental Apparatus, &c., in the (I.) Civil and Mechanical Engineering Department; (II.) the Electrical Engineering Department; and (III.) the Department of Natural and Experimental Philosophy, under the guidance respectively of Professor D. S. Capper, M.A., M.Inst.C.E. (Hon. Member), (and Professor H. M. Waynforth, Assoc.M.Inst.C.E.), Professor Ernest Wilson, M.I.E.E., and Professor Harold Wilson, F.R.S., by whom the subjoined particulars have also been obligingly furnished.

At the conclusion of the visit the members were entertained to tea, and Mr. F. R. Durham took the opportunity of expressing the thanks of the Institution to the Professors for the kindness they had shown in receiving them and in doing so much to make the afternoon so instructive and enjoyable.

Professor Capper having responded, the party shortly afterwards dispersed.

The Engineering Laboratory equipment includes the following apparatus: (*a*) for testing materials and obtaining a thorough knowledge of their nature and properties—A 25-ton testing machine, wire testing machine, torsion machine, journal friction testing machine; (*b*) for thermodynamic work; 60 I.H.P. Marshall experimental compound engine, 20 kilowatt Belliss Siemens' direct driven alternating current or direct current set, Parsons' steam turbine and direct driven dynamo, Davy Paxman semi portable locomotive boiler, Babcock Wilcox water tube boiler, Dowson suction gas plant, Crossley high-speed gas engine, condensing plant including centrifugal circulating pump tube condenser and Klein air and water pump, Junkers' calorimeter, Legros' calorimeter, apparatus for flue and exhaust gas analysis, Co_2 refrigerating plant; (*c*) hydraulic testing, hydraulic tank and apparatus for determining critical velocity of water, metacentre, &c.; (*d*) *General*—apparatus for determining the cutting power of tools, efficiency of machine tools and of belts and pulleys, and apparatus for determining the effects of blows on springs, apparatus for determining resisting power of asphalte.

The Siemens Electrical Engineering Laboratory contains very complete and modern apparatus which enables students to receive practical instruction in every branch of electrical engineering. Direct currents for experimental purposes are taken from the supply company's mains, also from a battery of storage cells (chloride) and from a Siemens 50 kilowatt compound wound 4-pole generator 500 to 550 volts. Alternating currents are taken from a Siemens 100 kilowatt 8-pole revolving field type alternator specially arranged to give 1, 2, or 3-phase currents at frequencies ranging from 50 to 25; also from two Siemens generators, each of 10 kilowatt output, with a special coupling which allows the phase displacement of the armatures to be altered. The power for driving purposes is derived from supply company's mains and transmitted from the motors by shafting capable of dealing with 100 H.P. at 250 revolutions per minute. There are a large number of machines of all types, available for experimental purposes, including direct current machines, 1, 2, and 3-phase induction motors by various makers, rotary converters, single-phase commutator motors, transformers, &c., and a complete tram-car equipment fitted with two 35 H.P. motors with arrangements for testing draw-bar pulls, efficiencies, &c. The laboratory is provided with an overhead travelling crane and a pit 30 feet long, 7 feet wide, and 4 feet deep, specially arranged for testing purposes, in addition to a standard car pit for dealing with the tram-car equipment.

Wheatstone Laboratory.—The equipment of this Laboratory includes a dark room for optical experiments, a workshop for the construction and repair of apparatus and a large number of apparatus (including the George III. and Wheatstone Collections) suitable for experimental work in all branches of Physics. The collections include many interesting historical instruments, among which the following may be specially mentioned: (1) the Daniell Lodestone which belonged to Daniell and was used by Faraday in his experiments on the induction of electric currents; (2) coils of insulated copper strip used by Henry in his experiments on induced currents; (3) rotating mirror used by Wheatstone in his experiments on the velocity of electricity along wires; (4) the original Wheatstone's bridge; (5) Wheatstone's original resistance boxes; (6) Clerk-Maxwell's dynamical model to illustrate the induction of electric currents.

AUTOMATIC FIRE EXTINCTION.

The Seventh Meeting of the Twenty-seventh Session was held at the Royal United Service Institution, Whitehall, on Friday, 13th March, 1908, the attendance being 78.

The Chairman, Mr. Frank R. Durham, took the chair at 8 p.m., and the minutes of the previous meeting were read, confirmed, and signed.

It was announced that since that meeting the following had been elected to the Institution, viz.:—

Members.

John Henry Currie ...	...	Brondesbury.
Stanley Moncœur Hills ...	...	Leyton.
Charles Warburton Jackson	...	Bournemouth.
Ernest Edwin Jeavons ...	...	Birmingham.
Morris James Harvey Molyneux	...	Wimbledon.
George Edward Mullard	...	Uttoxeter, Staffs.
Norman Samuel Trustrum	...	Brondesbury.

Associates.

John Francis Earle ...	...	Merton.
Reginald John Fisk ...	...	Lewisham.
Earl Maiden ...	...	Balham.
Maurice Stroda ...	...	Streatham.
Bernard Seymour Tharp	...	Leytonstone.

Before calling on Mr. George T. Bullock (Vice-Chairman) for his paper on "Automatic Fire Extinction as Applied to Factories," the Chairman alluded to the fact that he had kindly completed it for presentation at this meeting in order to enable Mr. G. H. Hughes to postpone his paper on "The Purification of Water" till the 7th April, the date announced for Mr. Bullock's paper.

A vote of thanks to the Author was proposed by Mr. J. H. Pearson, seconded by Mr. Charles W. Pettit, and was carried by acclamation. The other speakers in the discussion were Messrs. G. C. Allingham, J. W. Spiller, J. E. O'Brien, B. E. D. Kilburn, F. D. Napier, A. W. Marshall, James Sheppard, A. J. Simpson, Johnston, Heally, J. W. Nisbet, R. H. Parsons, L. F. de Peyrecave and Ridley.

The Author having replied, the proceedings terminated with the announcement of the ensuing visits on the 14th March to the New General Post Office Buildings, Newgate Street, and to Messrs. Mather and Platt's Fire Testing Station, Westminster, on the 16th March; and of the ensuing meeting on the 7th April, when a paper on "The Purification of Water" would be read by Mr. George H. Hughes.

Part 8. **MAY, 1908.** **Vol. XVIII.**

The Junior Institution of Engineers
(Incorporated).

President - - GUSTAVE CANET, M.Inst.C.E.,
Past-President Institution of Civil Engineers of France.
Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.
Telephone—
No. 912 Victoria.
39 Victoria Street,
Westminster, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

2nd May, 1908.

ANNOUNCEMENTS.

TUESDAY EVENING, 12th May. Meeting at 8 p.m. at the Royal United Service Institution, Whitehall, when a Paper, entitled "**The Design of a Sewer,**" will be read by Mr. Frank R. Durham, Assoc.M.Inst.C.E. (*Chairman of the Institution*), and discussed.

Advance copies of the Paper can be obtained on application by members desiring to take part in the discussion.

SATURDAY AFTERNOON, 16th May, at 3 p.m. Visit: The New Southwark and Bermondsey Storm Relief Sewer Works of the London Main Drainage, by permission of the Chief Engineer to the London County Council, Mr. Maurice Fitzmaurice, C.M.G. Members to assemble in the Contractor's yard, close to Tanner Street, Tower Bridge Road, five minutes walk from the Tower Bridge. Admission by Badge of Membership.

SATURDAY, 23rd May. Excursion to Bristol to visit the Avonmouth Docks Works, by permission of the Bristol Docks Committee through the Docks Engineer, Mr. W. W. Squire, M.Inst.C.E., and the Bristol Electricity Works, by permission of the Electrical Committee through Mr. H. Faraday Proctor, M.I.E.E., City Electrical Engineer. Train leaves Paddington at 8.20 a.m., returning from Bristol (Stapleton Road), at 8.5 p.m., arriving at Westbourne Park 10.27 p.m., and at Paddington at 10.34 p.m. Special tickets, 6s. 6d. return, to be obtained from the Secretary, **not later than Wednesday, 20th May.**

INSTITUTION ROOMS. The Rooms of the Institution are kept open **every Friday evening** during the months of October to May, inclusive, for purposes of social intercourse.

SUMMER MEETING IN FRANCE. The party leave London on Saturday, 27th June, returning Saturday, July 11th. The Outline Programme was issued with the March Journal. Arrangements will be made for members, who may so desire, to take one week only.

LECTURES ON SUCTION GAS PLANT. A special course of Three Lectures will be given at the East London College (University of London), on 27th May, 3rd June, and 10th June, 1908, at 8 p.m., by Assistant Professor C. A. SMITH, B.Sc. (*Member*). The subject matter will include:—Description of typical plants; methods of working; fuel used; applications; commercial figures concerning capital cost, depreciation and cost of working. The lectures will be fully illustrated, and have been arranged for engineers in practical work. Members of the Institution have been invited to attend free of charge. **Tickets may be obtained on application to the Registrar of the East London College, Mile End Road, E.**

Municipal, Building and Public Health Exhibition. The Organising Managers, Messrs. G. D. Smith and F. W. Bridges, have kindly invited the Members of the Institution to visit this Exhibition, which is being held at the **Agricultural Hall,** from 1st to 12th May inclusive. Tickets for use at any time can be obtained from the Secretary.

Changes of Address.

ARUNDEL, F. D., 12 Cadogan Road, Surbiton.
BLACKBEARD, D., Eldorado, Rhodesia, South Africa.
BLAKENEY, S. E., 53 Primrose Mansions, Battersea Park, S.W.
CARLEY, G., 55 Canning Road, Croydon.
CORREA, R., 19 Seymour Grove, Old Trafford, Manchester.
COSGRAVE, H. E., "Towyn," 16 Woodgrange Avenue, Ealing Common, S.W.
FELLA, E. A., 57 Oakfield Road, West Croydon.
GILL, J. O., 52 Earl Street, Shipley, Yorks.
HULME, C. T., 8 Douro Place, Victoria Road, Kensington, W.
KUPFERBERG, R. A., c/o The Bhutia Chang Tea Company, Post Panerihat, Darrang, Assam, India.
LAMBERT, L. C., Messrs. Yarrow and Co., Scotstoun, Glasgow.
MACPHERSON, W. D., "Inchcape," 17 Cavendish Crescent, Clapham Common, S. W.
MARTIN, G. W., "Ambleside," Broadfield Road, Hither Green.
MILLS, J. A., 34A Stapleton Road, Upper Tooting, S.W.
PETTIT, C. W., "Cheselton," Angel Road, Long Ditton.
SMITH, A. H. N., "Ashcroft," New Barnet, Herts.
THORNE, H. H., "Fenton House," 36 Fenton Square, Huddersfield.
THORPE, WILLIAM, 31 Wellington Road, Old Charlton, Kent.
WILLIAMS, C. G., 21 Almond Grove, Old Trafford, Manchester.

THE DURHAM BURSARY.

The Council have much pleasure in announcing the following terms of a Bursary which has been founded through the kindness of Mrs. Frank R. Durham :—

1. A Bursary to the value of £25 per annum (to be awarded, as hereinafter stated, commencing with the Session 1908-1909), is to be founded under the provision of Article 3* of the Articles of Association of the Institution, to encourage the younger members of the Institution in the pursuance of their studies in engineering and its allied sciences.

2. The Bursary may be competed for by all Members or Associates (as defined in Article 7,† paragraph "a" and the first twenty-five words of Article 7, paragraph "b," ending with the words "its allied professions") between the ages of 20 and 22 years, who are training for the engineering or an allied profession, be it by attending a regular curriculum or classes at a recognised Technical Training Institute, College, or University, or who are employed in a technical office or a works. The eligibility for competing for the Bursary terminates on the 23rd birthday.

3. The qualification for receiving this Bursary shall be a thesis, written in the English language, on some engineering, technical or scientific subject, chosen by the candidate.

4. The theses shall be adjudicated upon by an Adjudication Committee appointed annually by the Council, and consisting of the President, and Chairman for the Session, one Honorary Member, and two Senior Members of the Council.

5. The term of holding the Bursary shall be limited at the discretion of the Adjudication Committee to one year, or two years in succession; at the expiration of which term the Bursar will be expected to read a paper relating to some subject of his special study, or relating to practical experience acquired by him.

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* To accept, hold or manage any property or endowment which may be given, devised or bequeathed upon any trust or for any purpose which the Association may deem conducive to the promotion of the objects of the Association.

† (a) Candidates for admission as Members shall be persons who are engaged in the engineering or its allied professions.

(b) Candidates for admission as Associates shall be persons who, in the opinion of the Council, are preparing to enter the engineering or its allied professions . . . . . .

This paper shall be read and discussed at the last meeting of the session.

6. The Adjudication Committee shall be empowered to withhold the award of the Bursary if no thesis of sufficient merit be submitted. The monies thereby accruing, shall be awarded at the earliest opportunity as an additional Bursary or Bursaries.

7. The theses are to be in the hands of the Secretary not later than the 1st of September of each year.

8. The award shall be reported to the successful candidate by the 1st of October, and announced to the Institution at the Inaugural Meeting of each Session.

9. In the case of the Institution being dissolved, any monies held in trust on behalf of this Bursary shall be handed over to some deserving charity assisting necessitous members of the engineering profession; the Adjudication Committee in office at the time of dissolution shall nominate the charity in question.

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

BAKER, WILLIAM ERNEST; Messrs. The Projectile Co., Ltd. (1902), New Road, Wandsworth Road, S.W.

BRADLEY, WILLIAM ADDISON; Chapel Hill Lodge, Margate.

DENT, THEODORE; Sunderland Forge and Engineering Co., Sunderland.

EDWARDS, LEOPOLD; Messrs. Drew-Bear, Perks and Co., Battersea Steelworks, Battersea, S.W.

ELLIS, STANLEY WILLIAM; Messrs. Robert Warner and Co. [Engineers], Ltd., Walton-on-the-Naze.

FRANCIS, RONALD JOSEPH; Chief Engineer's Office, London County Council, Spring Gardens, S.W.

HAMP, JAMES ALEXANDER; Power Station, Metropolitan Railway, Neasden, N.W.

HEALY, LOUIS THOMAS; Electrical Engineer's Department, Royal Insurance Company, 28 Lombard Street, London, E.C.

SANDBERG, OSCAR FRIDOLF ALEXANDER; Mr. C. P. Sandberg, Palace Chambers, Bridge Street, Westminster, S.W.

SRINIVAS, G. VENKATACHALA; Messrs. The Shimoza Goldfields, Ltd. *Postal address*—Thamadihalli, Benkipur, Southern India.

Proposed for election to the class of "Associate."

ARBLASTER, GODFREY; Messrs. Belliss and Morcom, Ledsam Street Works, Birmingham.

DAVIES, OWEN; Messrs. The Lanchester Motor Co., Sparkbrook, Birmingham.

LLOYD, REGINALD; Messrs. The Lanchester Motor Co., Sparkbrook, Birmingham.

NEWSTEAD, STANLEY GRAHAM; Messrs. The St. Pancras Ironwork Co., Belle Isle, York Road, London, N.

STANDLEY, LAWRENCE EDWARD; Messrs. Robert Warner and Co. [Engineers], Ltd., Walton-on-the-Naze.

SWITHENBANK, ROBERT SCHOFIELD; Messrs. Redpath, Brown and Co., East Greenwich.

TOMLINSON, CYRIL WILLIAM; Messrs. Drew-Bear, Perks and Co., Battersea Steelworks, Battersea, S.W.

Member of Council for West of England. Mr. John W. Kitchin, Assoc.M.Inst.C.E., having left Bristol, has resigned his position of Member of Council for the West of England.

The Council have elected Mr. A. Don Swan, M.I.Mech.E., Resident Engineer, Avonmouth Docks Works, Bristol, to succeed Mr. Kitchin.

Appointments.

110. An Assistant Mechanical Engineer, not under 23 years of age, with knowledge of electrical machinery, is wanted for abroad. Good salary; three years' agreement; passage out and home.

111. An experienced engineer, with knowledge of electrical work, is wanted for bridge and roof design. Must have had training both in works and office, and be able to take full charge of office for designing new work, and expert in use of instruments in surveying and setting out.

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224. Member, age 26, Assoc.M.Inst.C.E., desires responsible position on works' staff, preferably as manager's assistant. Eight years' experience in all branches of manufacture and design of structural steel, bridge and roof work.

225. Member, age 21, mechanical Engineer, five years in the shops, two years' office experience, desires situation. Bristol or district preferred.

226. Member, age 21, desires engagement in a mechanical engineer's drawing office, four and half years' shop and drawing office experience; good theoretical training.

227. Member, age 30, fully qualified engineer, late assistant manager to well-known lift firm, is disengaged, owing to closing down of works, desires similar position. Good draughtsman, estimator and correspondent; used to control of men. Excellent references.

CORRESPONDENCE ON "THE ARCHITECT AND THE ENGINEER."

Mr. H. A. Stewart (Member) wrote, on the 27th April, 1908, from 8 Carlton Terrace, Swansea:—

I should like to congratulate Mr. P. J. Waldram on his able and instructive paper on the above subject, which was published in *The Journal* for March, page 329, and more especially on his supplementary observations in the current number, page 359, as to the "Extension of Committees of Selection to form Bureaux of Technical Information." I think this is where most of the technical societies overlook a splendid opportunity of usefulness. If our Institution were to take up this work, it would greatly increase the value of its membership, especially to those in the country. No doubt we shall have to look to the country soon if we still wish to further increase our membership, but what advantages has the Institution to offer to country members or members like myself, down in the country too far away to come up to the meetings? Certainly we have the Monthly Journal with its personal notes and comments, but if some scheme were in vogue, similar to that of the Surveyors' Institution, whereby in any technical difficulty arising we could be sure of having help from the Institution, it would be a great advantage and tend to keep the interest of country members alive, and also, what is more essential, enable them to introduce new members in the districts where they are working. I have myself tried to induce several friends to join, but have always been met with the remark that "the Institution has no personal interest for me, and the reports of the papers read are always given in the technical journals." If it could be shown that special technical assistance is included in the advantages of membership then the above objection (and it is a strong one) would be done away with.

Again, there is no doubt that a vast amount of practical information is locked up in the note-books of members, who would, I believe, be quite willing to draw upon it for the benefit of their fellow members to the mutual advantage of all. Such information noted is usually in regard to methods of overcoming difficulties of a practical nature, and I would suggest that a premium be offered for the best piece of personal practical

information sent in each month. As the scope of the Institution is so wide, the subjects might be classified into several divisions, so that each section of membership should be considered. At the end of the year suitable medals might be awarded, as is done for the best papers presented during the session. My ideas have only been roughly sketched out and could be easily elaborated. Of course the giving effect to them would cost money, but I do not think that any member would object to an increase in subscription for such a really useful purpose. Five shillings increase of subscription on the present membership of 1,000 would yield £250 a year, which should be ample.

FROM THE STARTING PLATFORM.

THE DURHAM BURSARY.

In another part of this number of *The Journal* will be found the announcement of a most handsome and generous gift which has been made to the Institution by Mrs. Frank R. Durham, the wife of our esteemed Chairman. To an Institution such as ours, the endowment is of inestimable value. Our ranks are composed almost exclusively of the junior members of the profession striving for a foothold on that part of the ladder where the crush is greatest. Although we pride ourselves, and justly so, on the fact that there is no other professional society existing, in which mutual services are more gladly and freely rendered than they are in our own, yet oftentimes the sort of help that a member most needs is such that he could not and would not accept from his fellows. During the early years of a young man's career he has to work hard, both mentally and physically if he means to rise in his profession, and frequently, in addition, he is harassed by the difficulty of making both ends meet. There are books to be bought and fees to be paid which press hardly on his slender resources, and many a lad is compelled to forego legitimate amusements and even the ordinary comforts of life to procure the means to acquire his education.

It is to afford assistance in cases of this kind that our generous benefactress has founded the "Durham Bursary." Our Institution with its large and increasing membership must always

have on its roll many to whom the *res angusta domi* is a very real thing. They do not talk of their needs, but those of us who have taken a share in the management of the Institution or who have otherwise had an opportunity of becoming acquainted with a large number of the members, know how sincerely they will appreciate the opportunity the Bursary puts in their way.

The object of the Donor is clearly indicated by the terms of the bequest. The grant is not intended either as a prize for the most brilliant man of the year, a reward for the most studious, or an inducement for the lazy to work. It is rather a beneficent gift, which may be proudly and honourably accepted by him who honestly needs it, and who has, at the same time, shown himself most fitted to profit by it.

Administered in this spirit, its value to the recipient will be untold. It will come at a critical period of his career, and may, not unlikely, give him just that help which will make so important a difference to his future. In fact, to the Junior Institution of Engineers there is no conceivable kind of gift which could have greater potentialities of good. This year will be looked back upon as a memorable one in our history for many reasons, not the least of which is the opportunity of doing good which Mrs. Durham's munificence has entrusted to us. We are most grateful to her for her generosity, proud of the faith she has displayed in the Institution, and resolved above all things that her confidence shall be justified.

R. H. PARSONS.

OBSERVATIONS IN GENERAL.

With the present number of *The Journal* is issued a form for the use of those hoping to join the party for Paris on Saturday, 27th June, as it is necessary that we should a month previously to the date of departure intimate to our President and other friends the number likely to avail themselves of the hospitality so kindly extended to us, as set forth in the outline programme.

* * * * * *

There are indications that the gathering will be a good one, but do not the exceptional circumstances of the invitation call for an exceptional response? The opportunity of a visit to Paris

under such auspices comes but very rarely indeed, and we believe that members will be ready to lay aside other holiday suggestions for 1908 when they consider the programme which the Institution is enabled to present, through the great kindness of M. and Mme. Canet, to whom we feel sure nothing will give greater pleasure in connection with our French visit than to hear that the number of acceptances for it has surpassed previous years.

* * * * * *

The ladies of the party will appreciate the promise of Madame Canet to so devote herself to their interests that all that is specially attractive to them shall be included in the programme for the day on which the members will be visiting Creusot.

* * * * * *

The scientific versatility of our Past-President the Hon. Chas. A. Parsons, C.B., F.R.S., of steam turbine renown, has been demonstrated in a paper which he has, with Mr. Alan A. Campbell Swinton, presented to the American Society of Mechanical Engineers on the subject of "The Conversion of Diamonds into Coke in High Vacuum by Cathode Rays."

* * * * * *

We notice the announcement of the formation of "The Concrete Institute," with a nucleus of one hundred founders. It is intended for those interested in questions of practice, research, and legislation affecting the use of Concrete and Re-inforced Concrete.

* * * * * *

Another new society on the stocks with expectation of launching on 10th June next, is the "Institute of Metals," the object of which is to advance knowledge of the non-ferrous metals and their alloys, more especially copper, zinc, tin, aluminium, lead, nickel, gold, silver and platinum.

* * * * * *

To our *confrères* across the Channel we offer heartiest congratulations on the Sixtieth Anniversary of the Institution of Civil Engineers of France, which is to be celebrated in Paris, from the 15th to 17th of the present month, under the presidency of M. E. Reumaux.

We observe with respectful pleasure that in the announcement of the result of the recent ballot for the election of Officers of the Institution of Civil Engineers, occur the names of our Past Presidents Professor W. Cawthorne Unwin, F.R.S., and Mr. Alexander Siemens as two of the four Vice-Presidents; and that amongst those elected as Members of Council are our Past Presidents Mr. J. A. F. Aspinall and Mr. William B. Bryan, and our Honorary Member Mr. Alexander Ross.

* * * * * *

May we not also note with gratification that although "at present" no "Member" of ours enjoys the distinction of having his name included in the list, nevertheless the father of Mr. Walter J. Hunter (Mr. Walter Hunter) and of our District Member of Council for the Scottish Districts, Mr. Harold E. Yarrow (Mr. A. F. Yarrow) have been chosen as Members of the Council.

AUTHOR'S REPLY TO DISCUSSION AND CORRESPONDENCE ON THE TESTING OF GAS ENGINES.

MR. GILBERT WHALLEY said that he felt greatly honoured by the reception which his effort had been accorded and by the presence of so many of the senior members of the Institution. When first invited to offer a paper, he understood that the meeting would be a special one for junior members only, and therefore hardly expected to have to address such a gathering as was assembled there that evening. He naturally felt pleasure on the occasion, and it had been enhanced by the circumstance of his having to acknowledge a vote of thanks, proposed by Mr. Tookey, his former chief, and seconded by Mr. Stanley Hughes, his colleague.

With reference to Mr. Tookey's remarks as to the noise usually associated with gas engine installations, there was no doubt that a great deal of it arose from the machinery which was being driven. In regard to "reversal of pressures" at page 385, to which Mr. Tookey had taken exception, he (Mr. Whalley) did not intend to convey that there was a reversal of pressures inside

the cylinder, but was referring to the sudden force brought into action tending to reverse the motion of the fly-wheel and crank-shaft. With reference to the removal of scale from the interior of a water jacket (page 393) he should have stated that the use of soda in the circulating water acted as a preventive of the formation of scale.

He thoroughly agreed with Mr. Lygo's observations on the position of belt drives and the mode of barring the engine when checking valve settings. He had had no experience with the Sellar's dynamometer, but had ascertained from those accustomed to testing with it that it was an extremely useful instrument, its chief features being portability combined with accuracy, so that it was to be preferred to the rope brake.

Mr. Evans raised some points regarding the injection of water into the exhaust pipe for the purpose of silencing an engine. The quantity of water required being only a mere dribble any increased diameter of the exhaust pipe was not necessary. Mr. Whalley regretted he had no figures available which gave the temperature of the exhaust gases after water injection. As to moisture on the ignition plugs preventing a spark being formed when starting an engine, this had in many cases been the cause of considerable delay and annoyance, and the simple remedy was to remove the plugs and warm them before starting up. Mr. Brewer had of course rightly pointed out that to enable a complete test to be made measurement should be taken of the compression space. With reference to his remarks on the calibration of the measuring instruments it would be understood that no one responsible for carrying out an accurate test would neglect the necessity of ascertaining that all the instruments were absolutely correct. The author wished to thank Mr. Brewer for exhibiting and explaining the Walker dynamometer and for showing the interesting set of wall diagrams. In reply to the doubt which he (Mr. Brewer) had expressed with reference to Fig. 12 (page 383), as the author had obtained so many diagrams showing the same result and all from different engines, he ventured to differ from him. Mr. Tookey's remarks on the subject in opening the discussion supported the author's views on this point. He (Mr. Whalley) could hardly agree with Mr. Brewer in his statement that under the influence of pre-ignition, the pressures obtained did not reach so high a value as under a

normal explosion, for the reason that diagrams taken while a pre-ignition was occurring showed that much higher pressures were reached than normally.

Replying to Mr. Stevens' question regarding the air resistance brake, the author suggested that possibly Mr. Brewer, who was well acquainted with the working of the instrument, would kindly furnish the particulars desired. As to the oil channel round the bottom of the engine frame, alluded to by Mr. Parsons, he was glad to say that several of the makers were now introducing this feature in their designs. He agreed that the wire gauge measurement of cylinder diameter was to be preferred to that which he had described in the paper. Mr. Parsons' method of counting the speed of a machine running at high speed was certainly a very useful wrinkle and well worth keeping in mind when no counter was available.

In reply to the discussion of the Birmingham Local Section, the author wrote that Mr. Knipe's method of ascertaining the length of stroke (page 364) appeared to be liable to greater error than that described in the paper (page 369). He hardly thought there was much to choose between the expression "sound of explosion" and "sound of exhaust," because after all, it was the sound of explosion which caused the sound of exhaust. In reply to Mr. Walshe as to the expression "reversal of pressures" mentioned under pre-ignition, the author referred him to the reply to Mr. Brewer in the London discussion, which dealt with the same point.

MR. ROBERT W. A. BREWER writes:—Referring again to Fig. 12 in the paper (page 383), which is entitled "Air Cycle," and comparing it with Fig. 2 in the discussion (page 402), I should like to make it quite clear that the latter refers to a series of operations which take place upon a burnt mixture which has been raised to a certain high temperature, and during the process, which is graphically described, the temperature is falling, owing to heat lost to the cylinder walls. Now in the case of Fig. 12, air is drawn in, and during the compression stroke is raised in temperature, owing, first to the action of compression, second, to heat gained from the cylinder walls, and third, to contact with products of combustion which have been retained in the cylinder from the previous explosion. Now the

fact as to whether the explosion curve will fall above the compression curve or not must depend to some extent upon the specific heat of the mixture within the cylinder, which consists in this case of air with a certain proportion of products of combustion, but comparing the two curves and considering that the specific heat of air at 100° C. is 0·169 per lb. = 0·0102 per cubic foot at 0° C., and that of the products of combustion (20·9 foot lbs. per cubic foot at 100° C.) = 0·0269 according to Mr. Dugald Clerk (1907) per cubic foot of mixture, at constant volume, or 0·0112 according to Professor Robinson (1902), it might happen that owing to the lower specific heat of the air the curve might rise higher after a missed explosion, *i.e.* when air only had been drawn into the cylinder, than would be the case if burnt gas alone remained in the cylinder. However, as the author had obtained diagrams showing this result and from different engines, I can only attribute it to the specific heat theory.

Referring to pre-ignition, I am afraid the author could not have clearly understood what I said. I did not make the statement that the pressures during the influence of pre-ignition "did not reach so high a value as under normal explosion," I said that in the ordinary way the pressure did not reach to so high a value as that indicated in Fig. 15 (page 386), for reasons given in the last paragraph of page 403.

With reference to Mr. Walker's dynamometers, these are made in four sizes, the largest absorbing up to 150 H.P., and the smallest up to 6 H.P. They are specially useful for high-speed engines, such as those for motor car purposes, and register correctly at all rates of revolution between 250 and 3,000 per minute. Taking the 60 H.P. size for example, this gives a maximum register of 57·5 H.P. at 1,000 revolutions per minute, 42 H.P. at 900 revolutions per minute, and the 30 H.P. size absorbs 24 H.P. at 1,000 revolutions per minute, with a maximum outside blade radius of 21 inches, 10 H.P. with radius of 16½ inches, 2 H.P., with radius of 11⅓ inches. These figures show the effects of both speed variation and blade radius, upon the capacity of the dynamometer.

The H.P. absorbed is shown on the curves relating to H.P. and speed in almost straight lines equidistant apart, each line representing the power absorbed when the blades are fixed in their several available positions. Taking now the 30 H.P. size and

assuming it is required to absorb 15 H.P. This can be done in either of the following ways, depending naturally upon the rate of revolution.

Blade Position, hole	15	13	11	9
Speed, Revs. per min.	1100	1160	1250	1350

Or the 60 H.P. dynamometer can be used as follows:—

Blade Position, hole	15	13	11	9	7	5
Speed, Revs. per min.	630	660	700	750	800	850

In the 60 H.P. and 30 H.P. sizes the plates are 8½ inches wide, but in the former are longer than the latter. From the foregoing figures the effect of the air resistance upon these flat revolving plates can well be conceived.

THE PURIFICATION OF WATER.

The Eighth Meeting of the Twenty-seventh Session was held at the Royal United Service Institution, Whitehall, on Tuesday, 7th April, 1908, the attendance being 56.

The Chairman, Mr. Frank R. Durham, took the chair at 8 p.m., and the minutes of the previous meeting were read, confirmed and signed.

A paper on "The Purification of Water" was read by Mr. George H. Hughes, M.I.Mech.E. (Member of Council for the Eastern Counties).

The Discussion was opened by Mr. T. D. Evans, who also proposed a vote of thanks to the author for his paper, which, seconded by Mr. J. N. Boot, was carried by acclamation. The other speakers were Messrs. J. G. Moon, F. D. Napier, J. J. Lassen, W. C. Wedekind and the Chairman.

The author having replied, the proceedings closed with the announcement of the ensuing visits on 11th April to the Purley Works of the East Surrey Water Company, and Exterior Fire Extinguishing Demonstrations in Leonard Street, and Wood Street, London, and of the ensuing meeting on the 12th May, when a paper on "The Design of a Sewer," would be read by Mr. Frank R. Durham (Chairman of the Institution).

"AUTOMATIC FIRE EXTINCTION AS APPLIED TO FACTORIES,"

By GEO. T. BULLOCK, A.I.E.E. (Vice-Chairman).

Read 13th March, 1908.

Introduction.—The Engineer or Architect in "laying out" works or factories will probably be called upon to consider the question as to the best and most effective means of preventing outbreaks of fire, and also of reducing to a minimum, the amount of damage likely to be sustained in the event of an outbreak occurring.

The questions are of paramount importance to every class of industry, for although provision by insurance may be made for damage done by fire, it cannot be said to compensate for any disturbance and dislocation of one's trade or business arrangements, be they manufacturing or otherwise. This paper is therefore intended to bring to the notice of the members of the Institution one of the most effective means of combating the ravages of fire, viz., extinction by automatic mechanical means.

Historical.—The history of fire extinction and prevention is very interesting, and may no doubt be said to date back to the time of King Alfred, whose law, known to all as the Curfew, was practically a precaution against fire. During the years prior to the Great Fire of London of 1666, regulations of a very primitive nature, such as "a barrel full of water for quenching fires to be placed before the doors of a building," and "bellmen to ring their bells at night, and call out, 'Take care of your fire and candle, be charitable to the poor, and pray for the dead,'" were put into force with the same object.

After the Great Fire various attempts were made to publicly deal with fire outbreaks by organising private brigades or bodies of porters provided with buckets, squirts, and parish and private fire engines ; but with the development of trade, together with the establishing and growth of cities and towns, the question of fire extinction continued to receive attention, and with the formation of properly trained fire brigades, the introduction of

powerful steam engines, public water supplies, hydrant systems, to say nothing of the numerous devices, such as hand grenades, pumps, fire alarms and chemical extincteurs, much has been done in that direction, but it would appear that men's minds were also occupied in designing something which should be independent of human agency, and deal with an outbreak in its initial stage, before it could assume dangerous proportions.

In 1763 a system was introduced to extinguish fires automatically. In 1806 an Englishman invented a system of perforated pipes with taps attached thereto manipulated by string, whilst in 1861 patents were obtained for sprinklers sealed with fusible solder, or a composition of wax, resin, or similar substances; but the information as to details is somewhat meagre, and does not point to the systems or sprinklers being practical; it does, however, enable us to see that the idea of extinguishing fires automatically is by no means of recent date. In 1864 another Englishman, Major A. Stewart Harrison, introduced a form of sprinkler sealed with fusible solder, many features of which were utilised in subsequent successful types.

To America, however, belongs the honour of originating a practical form of sprinkler. In the early 70's, Mr. H. S. Parmalee (who by the way was a pianoforte manufacturer) brought out a type known by his name, which was put into use in that country, and introduced into England about the year 1880, when, after many private and public tests, it was adopted

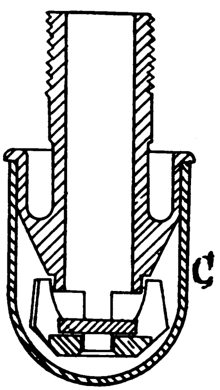


Fig. 1. PARMALEE.

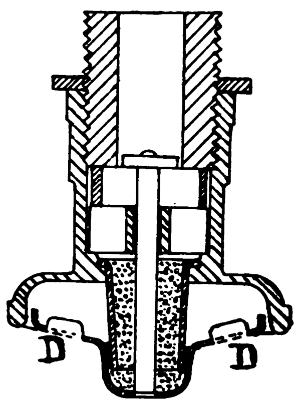


Fig. 2. VULCAN.

by one or more firms in the district of Bolton, and recognised by one of the Insurance Companies as deserving of some consideration in the premium charged for the insurance of premises so protected. This was of the "sealed type" (Fig. 1) which is now obsolete; it will be observed from the sketch that this type is valveless, the water being confined by a cap (C) soldered to the body of the sprinkler, and although it rendered good service, the type was doomed to failure owing to the necessity of heating the water, which was in direct contact with the soldered cap C, to the melting point of the solder before it could be released; whilst there was also a tendency for the cap to stick, unless the heat was fairly great, on account of the somewhat large area of the soldered surface.

The "Vulcan" (Fig. 2), an invention from Manchester in 1887, was also of this type, with the exception that a deflector (D) was fastened to a spindle and cap, which was also in contact with the water. It soon became evident that this type and form of construction was wrong, and various designs of valve sprinklers were patented, chiefly in America, in which the valve was secured by fusible solder free from contact with the water; in fact, about fifty different types in many varied forms have been introduced with little or much success. The first of the valve type to achieve success was introduced from America in

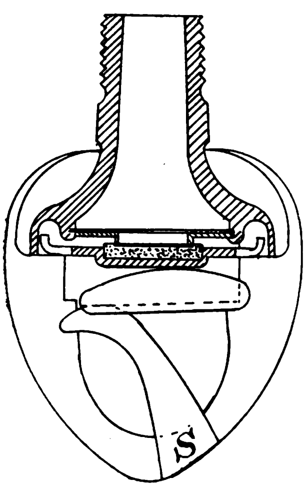


Fig. 3.

GRINNELL.

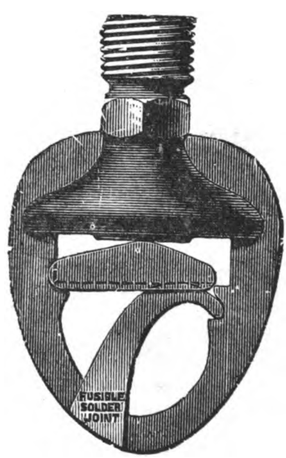


Fig. 4.

1884, and was known by the name of its inventor, "Grinnell" (Fig. 3 and 4); its chief and most important feature being its increased sensitiveness owing to the solder S not being in direct contact with the water. This sprinkler was soon recognised as a vast improvement upon the former types, and at that period practically formed the standard by which comparisons were made in testing other types. Many thousands were fitted throughout the country, and although various modifications have since from time to time been made in subsequent designs, it still holds a foremost position amongst those on the market.

Another sprinkler, the "Witter" (Fig. 5), was invented by a Mr. T. Witter, of Bolton, in 1885, and was of a similar class to the "Grinnell," but differed from it in construction.

The efficiency and reliability of automatic sprinklers having been proved, their application for protection of property became general, and they were adopted by Insurance Companies as an additional form of fire extinction, and in 1885, a pamphlet of instructions as to their application and erection for various classes of property was issued. This recognition soon brought many types into the field, each having some distinguishable

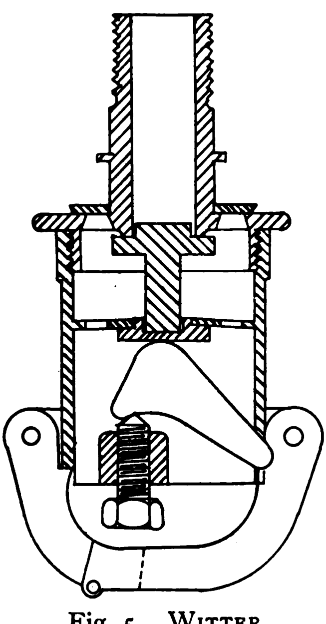


Fig. 5. WITTER.

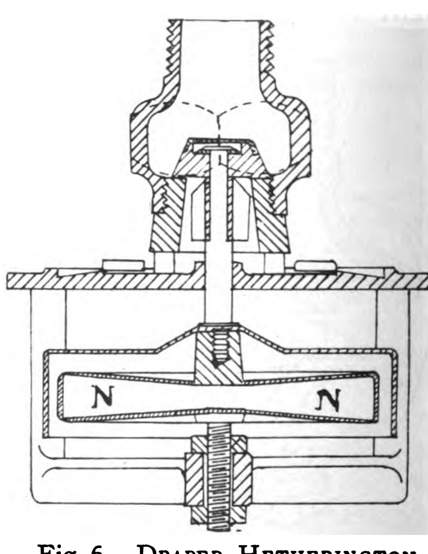


Fig. 6. DRAPER HETHERINGTON.

feature, among the foremost being the "Draper Hetherington" (Fig. 6), an ingenious device, which consisted of a head to which is attached a frame on which is fastened an expansion case (N) of thin brass, cylindrical in shape, the upper and lower covers being concave. This case contained a special mixture (alcohol, ether, &c.), which boils at a low temperature. When the air around the sprinkler began to be heated, the case expanded and raised the valve spindle, opening the sprinkler; when the fire was extinguished and the air cooled, the "case" contracted again, bringing the valve spindle on to its seat. Owing to the possibility of water being too promptly shut off by the action of the "expansion case," before the fire was fully extinguished, it was never officially recognised.

The "Garrett" was also of the self-closing type, and consisted of a tube within a tube, the outer one being expansive and the inner contractive. The heat expanded the outer tube, liberating the valve seat and opening the valve. A small quantity of water entering the inner tube contracted it, and it was so arranged that

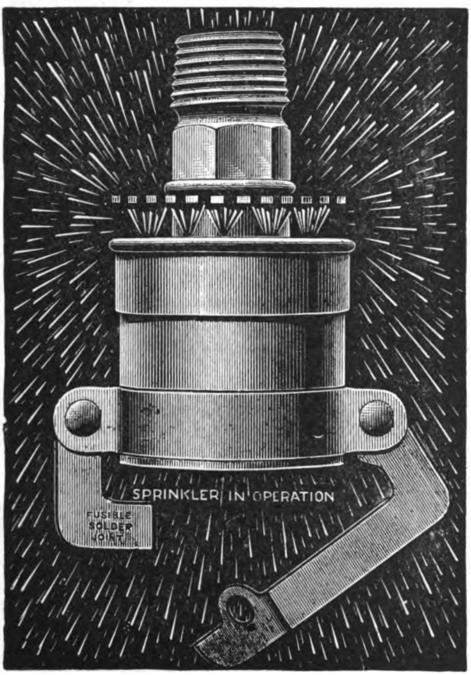


Fig. 7. WITTER.

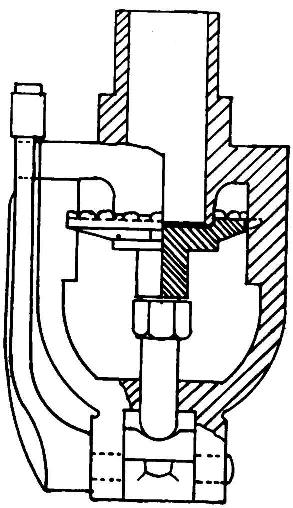


Fig. 8.
WALWORTH (LINK).

it was equivalent to doubling the expansion on the outer tube. Upon the extinction of the fire the valve reseated itself by the contraction of the outer tube, and thus shut off the water. Another type of which little was heard was the "Douse's patent fire check" (both electrical and automatic) which required chemicals, but these have never been recognised as fulfilling the stipulated requirements.

A sprinkler, in order to be considered of a perfect type and reliable under all conditions, should be simple in design, mechanically strong, the fusible joint having the maximum of sensitiveness, free from all possible contact with water, proof against leakage, and having an equal distribution over its area.

The type which came into general use, may be described as an apparatus, consisting of a metal body, to which is attached a fusible metal lever or strut supporting a valve, the soldered joint so arranged that at a given temperature it melts, and releases the valve, which allows water to pass through an outlet ($\frac{1}{2}$ inch diameter) on to a deflector or splash plate forming part of the sprinkler, distributing it over a given area in a shower or spray (Fig. 7).

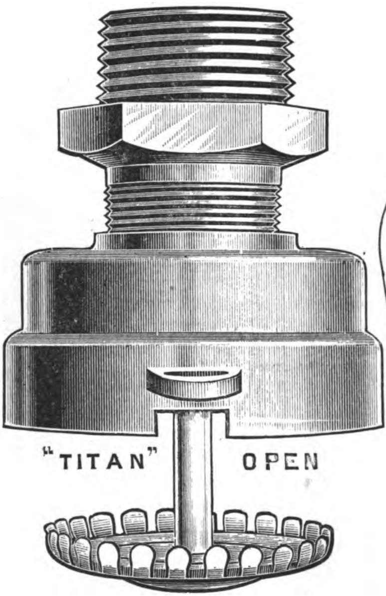


Fig. 9.

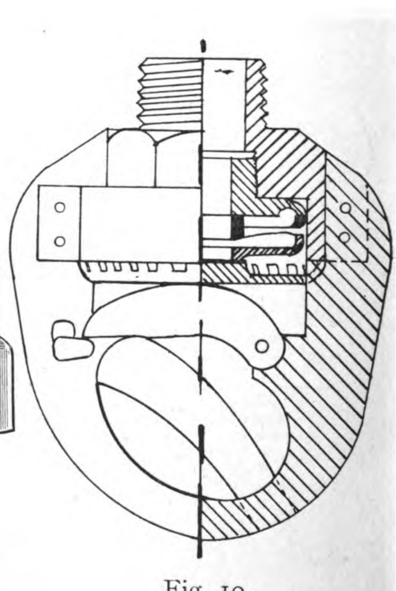


Fig. 10.
GALLOWAY.

The fusible solder usually employed acts at a temperature of 155° Fahr., and consists of :—

Bismuth	...	...	50 per cent.
Lead	...	...	25 ,,
Cadmium	...	...	13 ,,
Tin	...	...	12 ,,

The alloys are also arranged to act at other temperatures, such as in the case of drying rooms, stoves, &c., from 210° Fahr. upwards.

It is now interesting to note that in 1891, the following sprinklers, of which only the first four ever came into general use, were recognised as fulfilling the required conditions :—The Grinnell (Fig. 4), the Witter (Fig. 5), the Walworth (Fig. 8), the Titan (Fig. 9), the Galloway (Fig. 10), the Mayall (Fig. 11) and the Hudson (Fig. 12).

At the present time, those approved by the Fire Offices are the Grinnell (Figs. 13 to 15; there are three types, one being for high temperatures), the Witter (Figs. 16 and 17; two types, one being for wet pipe installations only), the Titan (Fig. 18),

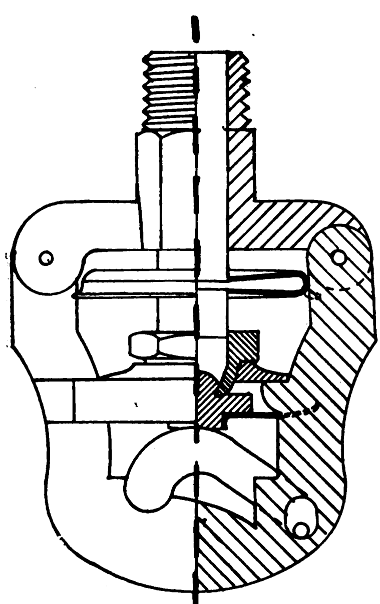


Fig. 11. MAYALL.

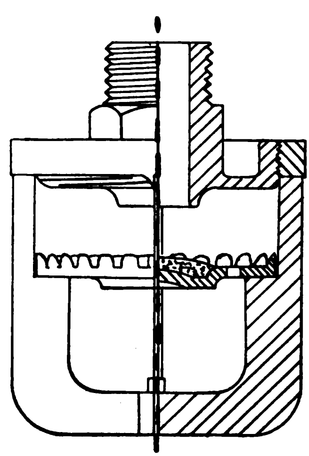


Fig. 12.
HUDSON.

AUTOMATIC FIRE EXTINCTION.

The Grinnell Sprinkler.

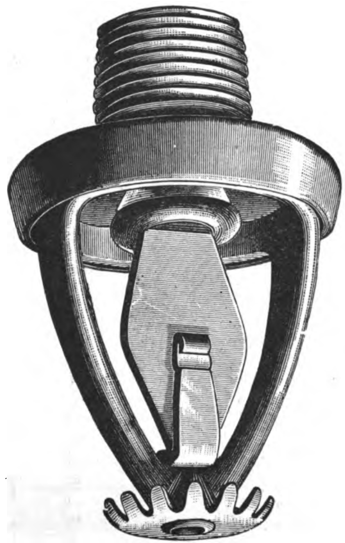


Fig. 13.
Closed,

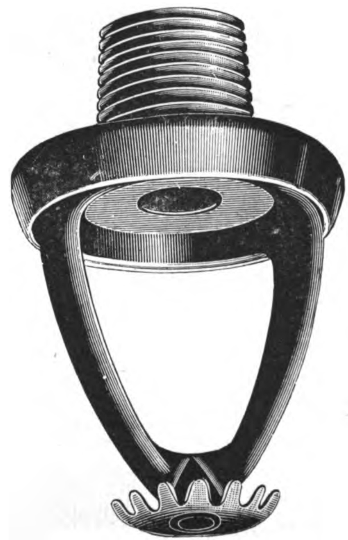


Fig. 14.
Open,

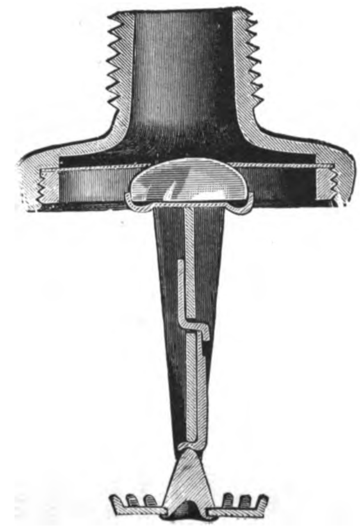


Fig. 15.
Vertical Section,

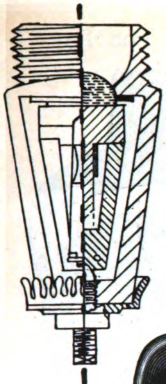


Fig. 19.
Beech.

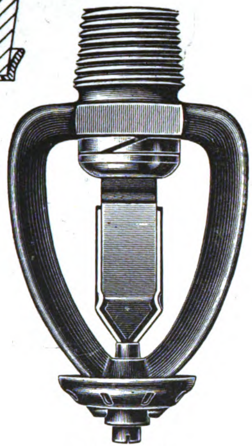


Fig. 16.
Modern Witter.

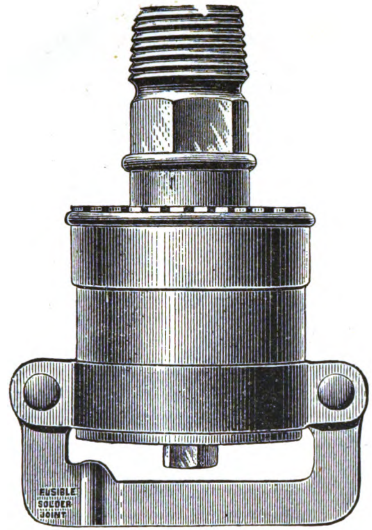


Fig. 17. Witter Type for Wet Installations.

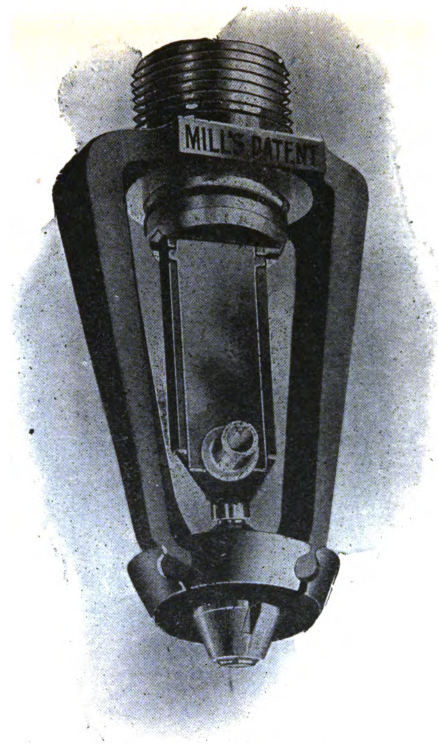


Fig. 18. Modern Titan.

AUTOMATIC FIRE EXTINCTION.

1. Valve.
2. Valve Cover.
3. Lever with two holes.
4. Lock Lever.
5. Lock Key.
6. Diaphragm.

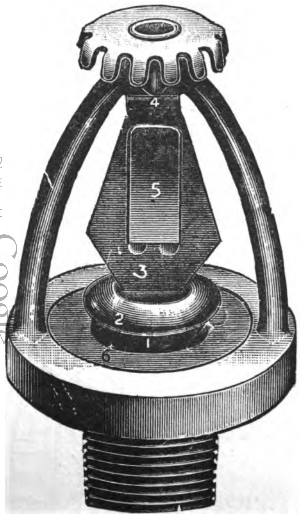
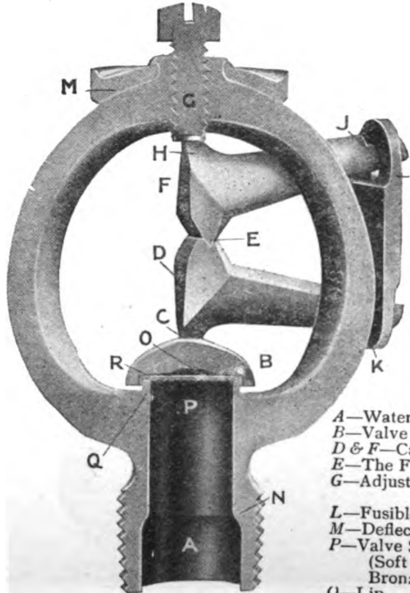


Fig. 20. HOFFMANN.

Fig. 21. HOFFMANN IN PARTS.



A—Water Way.
B—Valve Cap.
D & F—Cantilevers.
E—The Fulcrum.
G—Adjustment Screw.
L—Fusible Link.
M—Deflector.
P—Valve Seating (Soft Phosphor Bronze).
Q—Lip.

Fig. 22. MORRIS "B," 1907.

Fig. 23.
METROPOLITAN or GORTON.

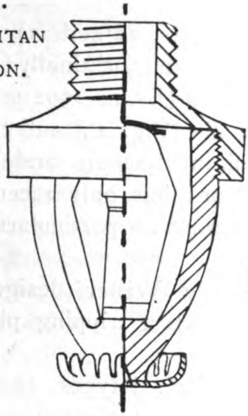
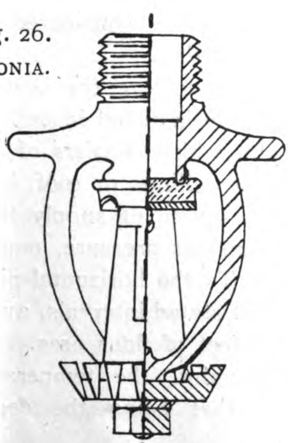


Fig. 24. INTERNATIONAL (Evans 1902 Model).

Fig. 25.
ALBION.

Fig. 26.
LACONIA.



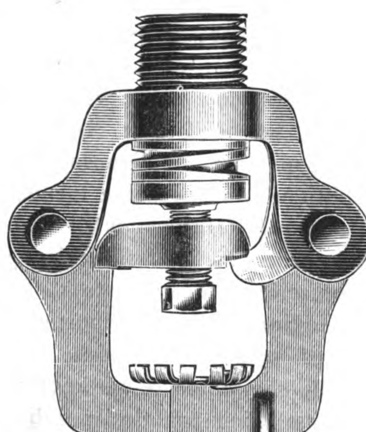


Fig. 27. WITTER 1898. Now fitted with a Tripping-piece on Deflector to ensure bridge-piece falling clear of sprinkler.

the Beech (Fig. 19), the Hoffmann (Figs. 20 and 21), the Morris "B," 1907 (Fig. 22), the Metropolitan (originally known as "Gorton"; Fig. 23), the International (Evans 1902 model; Fig. 24), the Albion (Fig. 25), the Laconia (Fig. 26) and the Record.

Of these, the Beech, Metropolitan, Laconia and Albion are now but little heard of; the Record has only recently passed the tests of the experts, and at present no particulars are available.

Reference may also be made to the Witter design of 1898 (Fig. 27), which is now provided with a tripping piece on the deflector.

The sketches obtainable of the principal types, show that the fusible joint is now kept clear of the water, the valve upon being released falling clear of the head. It will also be noticed that the valve in some types is kept in position by a direct strut composed of parts, whilst in others it is supported on the cantilever principle. Various advantages are claimed by the manufacturers for the particular type introduced by them, but it is not desirable in this paper to discuss the merits or demerits of each, having regard to the fact that they have each received the recognition of the Fire Offices, and when buildings are protected by an approved installation of any one of these types, a substantial discount is allowed on the premiums charged.

Having necessarily dwelt at some length with the historical side and types of sprinklers, it should be stated that although sprinklers have had a wonderful record throughout the world, it is not intended that they should take the place of ordinary extinguishing appliances, but are to be considered as an additional and valuable means of protection.

General Arrangements.—In order to achieve the best results it is necessary that sprinklers should be installed in buildings in a prescribed form (Plate 1, Fig. 28), which consists of a series of horizontal pipes supported near the ceilings or roof, and connected with rising mains, having a source of supply that will enable the water to be kept at a constant pressure, one supply at least being practically unlimited. To the horizontal pipes are attached the sprinklers or "heads" at stated intervals, averaging generally 1 to every 100 superficial feet of floor area. In the event of an outbreak of fire at any point, the temperature of 155° Fahr. is soon reached, and that being the degree at

which the soldered joint is ordinarily set, the solder melts, releases the valve of the particular head, each sprinkler acting independently. The water which is under pressure in the pipes is distributed on to the fire, and an alarm bell is rung, and continues ringing during the period water is flowing through the heads or the installation.

From this description will be easily understood the great advantage gained by such a system, which is able to automatically deal with an outbreak in its earliest stages and is not dependent upon individuals to direct extinguishing operations.

Two forms or systems of installations are in use—the wet and the dry pipe. In the former the installation is continually charged with water, and in the event of a fire acts as already described. In the latter the pipes in the buildings are filled with air at sufficient pressure on a valve to hold back the water in the supply pipe. Upon a sprinkler opening, the air escapes and releases the pressure on the valve, which is forced open by the water, which then flows into the installation, and through the open head. This system should only be adopted in buildings which are not artificially heated, and in which there is a possibility of the water in the pipes freezing. In such cases the heads are placed upright and above the pipe line, every pipe having a fall towards the waste or drain pipe, to drain off all water from the installation, the system being also arranged that not more than 700 sprinklers are controlled by one main stop and air valve. The dry pipe system is largely adopted in Russia, Canada and other countries having similar climatic conditions.

In some factories, however, it may be desirable to have water in the system for the greater part of the year, and air for such a period as when liable to damage by frost, when it is usually arranged to provide an alternate wet and dry system; this necessitating a slight re-arrangement of the valves, which will be described later.

When installing sprinklers, many points call for careful consideration and attention, the principal of these being:—Buildings needing protection; water supplies; spacing of sprinklers; pipe areas, valve connections and gauges.

Buildings Needing Protection.—The installation must extend to every building or portion of building forming one range by free communications, such as doors or other openings, and if the

party wall be not carried up through the roof, with the exception of shed buildings or those of fireproof construction.

Sprinklers must be provided in all concealed spaces, such as between ceilings and roofs, under galleries, non-fireproof stairways including the undersides, hoists, elevators, shoots, rope or strap races, gearing boxes, whilst in all factories having openings in the floor for belting, shafting, ropes or straps, a sprinkler must be fixed to command such opening, and dust or refuse exhaust trunks must have a sprinkler fitted inside the trunk to command the delivery side of the fan, except in textile mills where the trunks are constructed of incombustible materials.

In all cases where the top story of a building is open to the roof, the "heads" follow the pitch of the roof, and it is necessary to state that too much care cannot be exercised in having all concealed spaces in the roof adequately protected. In the early days of sprinkler protection fires have been known to occur in protected portions of the building, and the sprinklers have come into operation and successfully extinguished the fire in those portions. The stop valve has been shut down to prevent unnecessary water damage, when it has been discovered that the fire has got through the seat of the outbreak into the unprotected space in the roof, and the sprinklers being out of action (having no water supply) serious damage has resulted, and it may be safely inferred that this is likely to occur in all unprotected places of a concealed nature. Partial protection therefore cannot be considered satisfactory in any portion of factory buildings, more particularly those of non-fireproof construction. In this connection the following exceptions may be made as to protection, but it is not advocated that too much advantage should be taken of them. The author has knowledge of a fire which occurred in a fireproof room not protected in which damage to the extent of several thousand pounds was done, whilst in a non-fireproof room over, fitted with sprinklers, no damage was occasioned.

(1) Fireproof buildings, or portions thereof, forming distinct fire risks, or communicating only with the sprinklered building by fireproof door or doors.

(2) Non-fireproof buildings, or portions thereof, not communicating with the sprinklered building, otherwise than by

double fireproof doors in a perfect party wall carried through the roof.

(3) Fireproof staircases having all openings therefrom protected by doors, and

(4) Under certain conditions, shed buildings provided that the openings thereto from the sprinklered portion be protected by a fireproof door, or sprinklers.

WATER SUPPLIES.

Water Supplies.—These are of vital importance, for without good water supplies it can hardly be expected to obtain satisfactory results in case of an outbreak of fire. Water must be adequate, both in quantity and pressure, free from fibrous or other matter in suspension, the use of sea water being prohibited.

The approved sources of supply are:—(1) Towns' mains; (2) an elevated gravity tank, or private reservoir; (3) pressure tank; (4) pump; and (5) subject to special approval, an automatic injector apparatus connected with public or other approved hydraulic mains.

An ordinary installation has two separate and adequate sources of supply always available, one at least being practically unlimited and one automatic.

Until recently the only qualification needed for an approved installation of automatic sprinklers was that it should have at least two water supplies conformable to the requirements of the Fire Office, but in different parts of England it was found that this was not satisfactory, owing to the great difference in the type and quality of those supplies; in many instances, the supply and pressure was just sufficient to conform to regulations, whilst in others, it was more than adequate, both in the number of different water supplies, in addition to their class and quality, consequently standards have recently been arranged which receive the special consideration of the Fire Offices, the water supplies being from two independent sources, both automatic, and always available.

These standards are as follows:—

"A" One of the supplies must be from the town's main, or from an elevated private reservoir containing at least 200,000 gallons, and giving a minimum running pressure at the level of the highest sprinkler at all times during day and night of 25 lbs. to

the square inch, when the valve of the waste pipe is fully open, provided the proportionate reduction between the standing and running pressure does not exceed one-half, otherwise a minimum running pressure of 65 lbs. must be maintained at the level of the highest " head."

" B " (1) As in Standard "A," but with a minimum running pressure at the level of the highest sprinkler of 12 lbs. to the square inch, when the valve of the waste pipe is fully open, provided the proportionate reduction between the standing and running pressure does not exceed five-eighths, otherwise a minimum running pressure of 40 lbs. must be maintained at the level of the highest " head."

" B " (2) Neither source of supply being from town's main or elevated private reservoir. The two supplies, however, must be both automatic, and one of them from a practically unlimited source.

In some districts, it may be found impracticable to conform to any of the classes previously described. Installations may therefore, subject to special consideration, be arranged with "one water" supply, which must be automatic and derived from one of the following: (1) Town's main; (2) elevated private reservoir containing at least 50,000 gallons; (3) automatic pump, or (4) subject to special approval, an automatic injector apparatus connected with public or approved hydraulic mains.

The following indicate some of the usual methods of arranging the combined supplies:—

	Primary Supply.	*Secondary Supply.*
" A "	Town's Main.	Elevated Tank.
" B "	Town's Main.	Pressure Tank.
" C "	Town's Main.	Automatic Pump.
" D "	Elevated gravity tank or private reservoir.	Non-automatic Pump.
" E "	Pressure Tank.	Non-automatic Pump.
" F "	Two separate Town's mains supplied from independent sources,	

also similar combinations having an automatic injector apparatus as one of the supplies.

Having indicated the sources of supply necessary in an installation, it may here be of interest to enter into details as to each supply.

Town's Main.—In every district the public water supply will be found a variable quantity, and it is practically an impossibility to ascertain with accuracy for the purpose of this paper, particulars as to pressures and volume of water in the various localities, owing to the diversity of character of almost every district and the resources at the command of the water authorities. Assuming, however, that volume and pressure are satisfactory, the branch main, the minimum size required being that of the main installation feed pipe, is brought direct from the street main to the installation controlling valve, and is only available for the sprinkler, and, under special conditions, fire hydrant services, the latter arranged in such a manner that the pressure on the installation is not weakened thereby.

The size of the branch from the street main is determined by the greatest number of sprinklers in any one floor, or corresponding floors of communicating buildings. One pipe having a maximum internal diameter of one and a half inches, or its equivalent sectional area in smaller pipes, can be taken off the supply pipe for domestic or ordinary service. In some towns, factories may have two separate mains supplied from independent sources, and provided that the minimum size of each is according to the rule previously mentioned, they may be considered as a duplicate service, but if found to be insufficient in size, they would be deemed as one supply, if the connections from the two mains are, in the aggregate, equivalent in sectional area to the pipe required, and assuming that the capacity of the original supply to the mains is adequate. The use of a meter is not desirable, but if found necessary or compulsory, it, together with all valves, should be of at least the same size as the supply pipe, the meter and any stop valve being kept fully open for the supply to be considered automatic. It may be advisable as a precautionary measure to have a full bore bye-pass fixed at the meter, which could be opened in the event of fire. Water from this source must always be available, giving a minimum pressure at the level of the highest sprinkler in—

Standard installations—Running pressure as on pages 439 and 440.

In the case of two independent town's main connections, the running pressure in one case complying with the rule, then the

other must give a minimum running pressure of 5 lbs. per square inch at the level of the highest sprinkler.

Ordinary installations:—10 lbs. to the square inch standing pressure.

One Water supply installations—5 lbs. to the square inch running pressure, and provided that the proportionate reduction between the standing and running pressure does not exceed five-eighths.

Elevated Gravity Tanks and Private Reservoirs.—The capacity of these should be in accordance with the following rule:—

When the sprinklers on any one floor or on the corresponding floors of buildings communicating otherwise than by fireproof doors or shutters do not exceed 150 heads, 5,000 gallons; 200 heads, 6,500 gallons; exceeding 200 heads, 7,500 gallons.

In cases of "Standard" and "One Water" supply installations, private reservoirs are also subject to the special provisions previously named. (Pages 439 and 440.)

These quantities must always be kept solely available for sprinklers, but in the event of an excess quantity being provided arrangements may be made for the water over and above that required for the installation, to be drawn off for other purposes, the outlet for such, or overflow pipe, if any, being so arranged at such a height that the quantity of water cannot be reduced below the quantity specified for sprinklers.

In order to get the necessary head of water, an elevated gravity tank is placed so that its base is at least 15 feet above the highest sprinkler, and an indicator is fitted in a conspicuous position, showing the depth of water therein. The tank in all cases should be covered in, and provision made against freezing. In exposed districts it may be found necessary to utilize artificial heat, a small steam pipe being of service when available, in this connection. The tank is usually fed through a pipe of one inch diameter through any ordinary ball tap, and a permanent ladder should be provided to allow ready access for inspection.

It is essential that the tank should be thoroughly cleansed at least once a year, and care exercised to prevent deposits, or sediment from passing down the installation supply pipe, a strainer on the outlet being a suitable provision.

Pressure Tanks.—In some districts elevated gravity tanks cannot be erected, and many objections have been made to their erection on account of the probable necessity of providing special foundations for their support, the large expense liable to be incurred where the buildings are very lofty, and in some instances on account of the restrictions of the Building Act.

Pressure tanks have therefore been introduced to overcome these objections, and are employed where only one unlimited source of water supply can be provided.

A pressure tank (Plates 2 and 3, Figs. 29 and 30) is partly filled with water and charged with air under pressure sufficient to give 15 lbs. per square inch on the highest sprinkler, when all the water is discharged from the tank. The usual type is cylindrical in shape, about 28 feet long and 6 or 7 feet in diameter, according to capacity required; constructed of rivetted boiler plates, and fitted with air pressure and water gauge glasses (Fig. 29A details), the latter being provided with stop cocks kept closed, and opened only to ascertain the level of water in tank. These are kept closed as a precautionary measure against a damaged glass draining all the water or pressure from this reserve supply. The tank is charged with air and water by means of a pump or pumps; a combination air and water pump is sometimes used, and is quite suitable for the purpose; these are also required for making up any loss of water which may be occasioned in testing the alarm or the installation generally, or on account of air leakage, as frequently the pressure tank will be found to have the greater pressure and would actually come into operation as a primary supply, and thus be drawn upon when testing. The feed pipes, supplying air and water to the tank, are fitted with a stop valve and a back pressure or check valve, close up to the tank to prevent the loss of pressure or water other than through the installation proper.

The capacity of a tank or tanks must conform to one of the following:—

(1) 5,000 gallons—containing two-thirds or not less than 3,333 gallons of water and one-third air, at an initial minimum pressure of 75 lbs. per square inch when the base of the tank is level with the highest sprinkler.

(2) 6,666 gallons—containing one-half or not less than 3,333 gallons of water and one-half air, at an initial minimum

pressure of 45 lbs. per square inch when the base of the tank is level with the highest sprinkler.

(3) 10,000 gallons—containing one-third or not less than 3,333 gallons of water and two-thirds air, at an initial minimum pressure of 30 lbs. per square inch, when the base of the tank is level with the highest sprinkler.

The pressure tank should be placed as high as possible within a protected building, the top story for preference, properly protected against frost, and in such a position to give free access on all sides. It will be observed that it may be impossible under the above condition to have the base of the tank on a level with the highest sprinkler, and should it be necessary to place the pressure tank at a lower level, in order to maintain its efficiency relative to the top sprinkler, it will be necessary to provide additional air pressure for each foot or part thereof of which the base of the tank or tanks is below the highest "head," the rule being applied as follows:—

No. 1 Tank	$1\frac{1}{2}$ lbs.	per sq. in. for every foot or part thereof.
No. 2 Tank	1 lb.	,, ,, ,,
No. 3 Tank	0·75 lb.	,, ,, ,,

In all cases where arrangements can be made on the lines indicated, viz., the tank placed on the top story, the smallest capacity tank (No. 1) is usually installed, but occasions may arise when the tank may have to be placed at a considerably lower level; under these circumstances it will be found advantageous, in order to avoid too great an air pressure in the tank, to utilize size No. 2, which has different ratios of air and water.

In all cases where the position of the tank exceeds say 80 feet below the highest sprinkler, a system for avoiding too great an air pressure is permissible, viz., to utilize two tanks of No. 1 class, containing in all not less than 3,333 gallons of water, but at the pressures given for No. 3 class, thus minimising the working pressure to be maintained.

As already stated the minimum air pressure has been fixed to enable the last of the water to be discharged from the tank at a pressure to give 15 lbs. on the highest sprinkler, and taking the smaller capacity tank (No. 1) as an example, which requires 75 lbs. per square inch, assuming the base of the tank to be level with the highest sprinkler, the calculations are arrived at

in the following manner:—The unit of atmospheric pressure being approximately 15 lbs. is added to the 15 lbs. pressure required, making the terminal pressure 30 lbs., this multiplied by the amount to which the volume of air can expand when the tank is empty, in this case 3, gives a total of 90 lbs. per square inch. The atmospheric pressure is then deducted, which leaves 75 lbs. per square inch as the minimum air pressure to be maintained.

If the base of the tank mentioned in this example is say 12 feet below the highest sprinkler, it will require a further air pressure of 18 lbs. per square inch (12 feet at $1\frac{1}{2}$ lbs. per square inch) to be added to the 75 lbs., making 93 lbs. as the minimum working pressure necessary to be maintained.

Pumps.—These are usually of the horizontal duplex double acting plunger type (Plate 4, Fig. 31), although any other types are permissible, subject to the output being the same as that required for those of the standard type.

The required capacity is as follows:—When the sprinklers on any one floor, or on the corresponding floors of buildings communicating otherwise than by fire-proof doors or shutters do not exceed 100 heads, 250 gallons per minute; 200 heads, 500 gallons per minute; exceeding 200 heads, 625 gallons per minute. Where buildings are likely to be extended, or additional premises erected, necessitating the development of the sprinkler system, pumps of a larger capacity than that actually required by rule are strongly recommended.

The location of a pump house or room should be carefully considered, as the pump should be placed in such a position as to be free from damage by fire or accident, and easily accessible.

Water must be obtained from a practically unlimited source, usually a reservoir, river or other large body of water where available. In large towns it will probably be found necessary to provide a suction tank fed from the town's main. In such cases an equilibrium ball valve should be fitted, the minimum capacity of such tank being one hour's supply. Where the capacity of a suction tank is in excess of that required for the installation and the excess is drawn off for other purposes, the outlet for such purpose is so arranged that the quantity in the tank is not reduced below that necessary for the sprinkler service.

Steam should always be available at an efficient pressure to obtain the maximum output, and a pressure gauge fixed on the delivery pipe on the pump side of the back pressure or check valve on such pipe. It is recommended that independent connections be provided from the boilers, and where factories have more than one boiler, the steam pipes and valves should be so arranged that each boiler can be disconnected without affecting the supply from the others.

In the case of standard installations, or where the town's main or a hydraulic injector apparatus is one of the supplies, the pump is provided with an automatic attachment and is constantly moving under steam. The automatic regulator is so fixed on the steam supply pipe to the pump (Plate 4, Fig. 32) that when one or more sprinklers come into operation the main steam supply is automatically opened and the pump comes into working condition in ratio to the number of sprinklers operating through the fire.

In factories having ample electrical equipment, turbine fire pumps are being introduced (Plate 4, Figs. 32A and 33). These are made to correspond with the standard type, and are also designed for any particular conditions required. Many advantages are claimed for this class of pump, principally in connection with the space required and the economical cost, both as regards the initial charges and cost of running.

The electrical current, however, must always be available from two distinct and independent generating sets, the current being conveyed to a point on the premises by separate mains, and in the event of the sets being in the same power house or room, it would be necessary to submit the case to the Fire Office for special consideration.

In the case of standard installations, the pump should have a minimum steam pressure of 40 lbs. per square inch always available; a full size "bye-pass" steam pipe round the automatic valve with stop valves so arranged that when the automatic valve is not available, or at the time of a fire, the pump can be worked independently of the automatic valve; the automatic regulator should also be set so that the pump will accelerate its speed, when the pressure at the level of the highest sprinkler is reduced to less than 25 lbs. per square inch.

A foot valve is provided, when the pump is above the level of

its water supply, and an efficient "priming" arrangement is always available. The pump must also only be used in connection with the sprinkler installation, fire hydrants or boiler feed. A stop valve on the delivery pipe is only permissible when the other water supply is either an elevated gravity or a pressure tank.

Hydraulic Injector Apparatus. (Plate 4, Fig. 34.) The author has had no experience with this apparatus, but the following particulars have been obtained through the kindness of a well-known sprinkler expert.

"The apparatus is, as it were, a pump, but deriving its power from a hydraulic supply in place of a steam supply. A high pressure connection is brought in from the hydraulic power mains to the apparatus, and passes through two Greathead injectors, having orifices of about one-half inch in diameter, into a larger chamber. Into this chamber connections are brought from a suction tank, or other low pressure supply, and the high velocity of the high pressure water passing through the small orifice into the larger chambers, causes a partial vacuum therein, and sucks a quantity of low pressure water into this larger chamber; the high and low pressure water thus mixed together, passes through the delivery pipe to the sprinklers. The apparatus is so designed that by means of a weighted piston connected to the delivery, the pressure on the delivery is reduced to a suitable figure, usually about 85 lbs. to 90 lbs. per square inch. There are both spring and weighted safety valves fixed on the delivery pipes, which make it impossible for any excessive pressure to get past the apparatus."

The regulations as to the position and capacity of the apparatus are similar to those governing pumps. Water is obtained from an available unlimited source, a direct connection with the town's main being preferable; in some districts this may not be allowed, so that a suction tank is utilized and is automatically fed, the capacity of such tank being as follows:—

An apparatus	delivering	250 galls. per min.	2,000 galls.
,,	,,	500 galls. per min.	3,000 galls.
,,	,,	625 galls. per min.	4,000 galls.

The minimum size of the town's main and connection of the apparatus and feed pipe to the suction tank is arranged accord-

ing to the greatest number of sprinklers on any one floor, or corresponding floors of communicating buildings as per table on page 451.

If, however, the other source of supply is the town's main, the capacity of the suction tank is in accordance with the requirements for elevated gravity tanks. (See page 442).

The minimum pressure required on a hydraulic main used for this apparatus is 600 lbs. to the square inch, and it is therefore necessary to have a pressure gauge fixed on the hydraulic connection thereto. The accumulator is also fitted with a small outlet or drip, so that it is in constant motion, or will come into action at regular periods, an indicator being fixed to show the number of strokes made by the accumulator, the object of the accumulator being to operate the inlet valve on the hydraulic supply to the injector.

Spacing of Sprinklers.—As previously mentioned, in factory buildings one sprinkler head is usually fixed to every 100 square feet of floor area. In buildings of non fireproof construction, the heads are placed not more than 10 feet apart, 5 feet from walls, or partitions carried up to the ceiling, or 4 feet if the external walls be of wood, or of iron lined with wood, and the deflectors within 12 inches of the ceiling.

In buildings of fireproof construction, the heads are placed not more than 12 feet apart, 6 feet from the walls, and the deflectors within 18 inches of the ceiling, the measurements being taken in the case of open-joisted ceilings from the undersides of the joists, and in the case of fireproof arched construction, from the crown of the arch.

It is of great importance in spacing the heads in roofs or ceilings divided into bays by joists, beams or arches, and also where transverse beams are used, to so arrange that the whole of each bay is fully and adequately protected, and in some instances, owing to the erection of fittings, racks, machinery, &c., a larger number of sprinklers may be necessary than are actually required by area.

Owing, however, to the varied formations adopted by architects and engineers in constructing such bays, special provision has been made in such cases, as set forth in the following table, and it is applicable where the undersides of any beam (1) of a

ceiling or roof (not open-joisted nor having common rafters exposed) are more than 3 inches below the ceiling; (2) of a flat fireproof ceiling or roof are more than 6 inches below the ceiling, and (3) of an arched fireproof ceiling or roof are more than 12 inches below the ceiling.

SPECIAL SPACING OF SPRINKLERS.

In the case of roofs or ceilings in bays.	Width of bays in feet from centre to centre of beam.	No. of rows required in each bay.	Maximum distance of Heads. Across the bays.	Down the bays.	From face of heavy beams or from walls parallel with bays.	From walls at end of bays.
			ft.	ft.	ft.	ft.
Underdrawn with plaster, wood or metal, or constructed of planks without joists	not over 8	1	8	12	6	6
	over 8, not over 10	1	10	11	6	6
	over 10, not over 11	1	11	11	6	6
	over 11, not over 22	2	11	11	6	6
Open joisted or having common rafters of roofs exposed	not over 8	1	8	10	5	5
	over 8, not over 10	1	10	10	5	5
	over 10, not over 11	1	11	8	5½	4
	over 11, not over 22	2	11	10	5½	5
Of fire-proof construction	not over 11	1	11	12	6	6
	over 11, not over 12	1	12	11½	6	5
	over 12, not over 24	2	12	11½	6	5

NOTE.—Corn Mills are not included in this Table.

It is essential that the "heads" should have full scope for operation and free play for the water; care must therefore be exercised in erecting fittings, &c., likely to hamper their distribution. A clear space of 12 inches should always be preserved below the "heads" throughout the whole area of each room.

Pipe Areas for Supply and Distribution.—Pipes vary in diameter from $\frac{3}{4}$ inch to 6 inches, according to the number of "heads" required, and are usually of wrought iron with cast iron fittings, capable of withstanding a pressure of from 200 lbs. to 300 lbs. to the square inch. They should be securely fixed or suspended, and it is advisable to paint them as a preservative against rust, a distinct colour being also used to prevent the possibility of pipe connections being inadvertently made for any other purpose, as all pipes above the main stop valve, must be strictly confined to the sprinkler service only.

The size of an installation is governed by the greatest number of sprinkler heads in any one floor, or series of freely communicating floors, every head being included in this calculation, whether under staging, racks or galleries.

The area of the main supply pipe is also governed by the same rule, consequently, an installation having 100 sprinklers on any one floor, or series of floors so described, would require a 4-inch main supply pipe; or an installation of over 150 sprinklers on a floor, or floors so described, a 6-inch main supply pipe. In very large works or factories having many separate blocks of buildings, it may be necessary to arrange for two or more installations; this would not, however, involve separate sets of water supplies.

The following table, which has been adopted by the Fire Offices and sprinkler engineers, indicates the minimum size of main supply and distributing pipes according to the number of sprinklers required to be fitted.

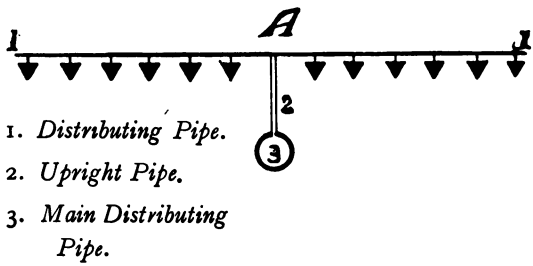
SIZES OF MAIN SUPPLY AND DISTRIBUTING PIPES.

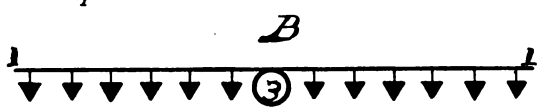
SIZE OF PIPE.	SPRINKLERS ALLOWED.	
	Table "A." Applicable to all cases except as specified in Table "B."	Table "B." Applicable to Drying Stoves and Drying Rooms where the maximum temperature exceeds 100° Fahr.
$\frac{3}{4}$ inch	1	1
1 ,,	3	2
$1\frac{1}{4}$,,	5	4
$1\frac{1}{2}$,,	9	6
2 ,,	18	12
$2\frac{1}{2}$,,	28	16
3 ,,	46	28
$3\frac{1}{2}$,,	78	No pipe to exceed three inches. If more than 28 sprinklers are required, more than one feed pipe must be provided.
4 ,,	115	
$4\frac{1}{2}$,,	125	
5 ,,	150	
6 ,,	over 150	

In factories where extensions are possible, or additional heads are likely to be required in consequence of the erection of extra fittings, machinery, &c., much expense and inconvenience may be saved by having the feed pipes somewhat larger than the minimum required by rule.

The chief point to be considered in arranging the feeds on the various floors, is that each section shall obtain its full volume and pressure of water, and the distributing pipes are set out so that not more than 12 sprinklers are fed in one row, but where the distributing pipe is taken off a riser connected with the main feed, as in diagram "A" (p. 452), 6 heads only must be fixed on either side of the riser, the same rule being also applied when the

distributing pipe is taken direct off from the main feed as in diagram "B." The object of this is to be certain that each sprinkler, including those farthest away from the main, is receiving its full supply of water.





Valve Connections. (Plate 5, Fig. 35.)—Every installation is controlled by various stop, check, drain and other valves, and it is obviously necessary that these should be accessible both for inspection and in case of repairs being needed, provision also being made against frost. The main stop or sluice valve controls all water supplies to the installation, and is placed in a prominent position near to the ground level, and secured open by a rivetted or padlocked strap; a very necessary precaution which, whilst preventing unauthorised persons shutting off the water supplies, or otherwise tampering with the installation, would permit in the case of an emergency the valve being shut by simply cutting the strap; the valve should also be provided with an indicator to show whether it is open or shut.

The water supplies are connected together before passing through the main stop valve, but in wet installations where a non-automatic pump forms one of the sources of supply, the pump may be connected at the most convenient point available. It is essential that each main supply pipe should be provided with a back pressure or check valve (see sketches, Figs. 36A and 37A); this prevents water passing from one supply to the other, more particularly when the town's main is one source of supply and the water is not available from the main, owing to a breakdown or other causes.

Back Pressure Valves.

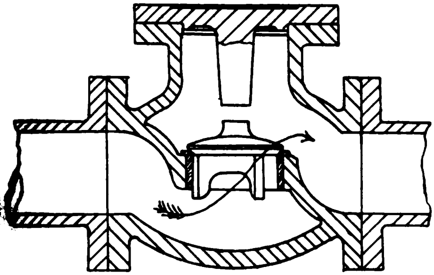


Fig. 36A.

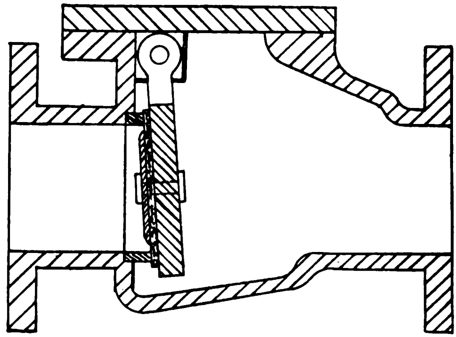


Fig. 37A.

Above the main stop valve is fixed the alarm valve (see sketch, Fig. 38A), a type of check valve, automatic in its action, being opened and closed by the flow of water in the main feed. There is a small groove in the valve seat, to which a small pipe is attached, connected to a turbine, and water flowing through this pipe drives a spindle on which a hammer is fixed, striking an alarm gong. This gong is fixed in a prominent position outside the building, and will continue to ring while there is any flow of water through the installation from an outbreak of fire or accident to the pipes or sprinklers. It will be found necessary to frequently test this alarm, and for the purpose an ½ inch test cock is fitted on the feed pipe to the alarm gong.

Above the alarm valve again, is provided a 2-inch drain valve and waste pipe, for emptying the installation when required, and as the area of this pipe is equal to 18 sprinklers it is used for taking the running pressure of the installation.

An installation under the alternate wet and dry pipe system would require an air valve fixed between the alarm valve and the 2-inch drain valve, the latter being so placed that all water can be drawn from the installation before putting it under air. A test valve or cock for the alarm in such cases is fixed on the installation side of the air valve, in addition to one previously mentioned.

The principle of an air or dry pipe installation has already been described, but it may be of interest to note the governing features

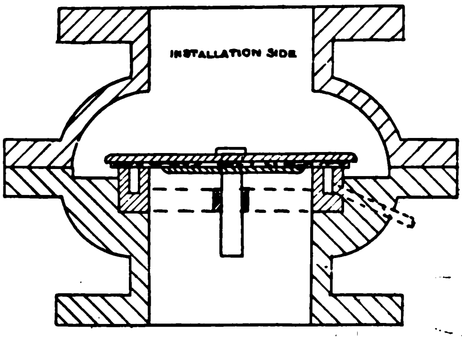


Fig. 38A. *Alarm Valve.*

connected with the principal air valves introduced and fixed by Sprinkler engineers. It is important to note that an air valve, in order to be considered reliable, must withstand any fluctuation of water pressure with a fixed air pressure.

In the Grinnell differential air valve (Plate 5, Fig. 36) the valve A B has two seatings connected by a spindle moving as one, the lower seating A holding in check the water supply by air pumped into the installation exerting a pressure on the upper seating B, which is approximately eight times larger than A, the ratio of air pressure being 25 lbs. to 100 lbs. per square inch of water pressure. A water seal is provided to the air seating by pouring a small quantity of water through the inlet M up to the level of E. The opening of a sprinkler allows the air in the pipes above B to escape, the water pressure lifts the valve A B, and water passes into the installation pipes to the open sprinkler, and to the alarm. The valve is held clear of its seatings to give a full water way by a catch, which springs on to notches or stops of an upright G. The valve can be reseated by removing the hand hole cover L, which gives access to the atmospheric chamber H.

In the Witter automatic water valve for dry pipe installations (Plate 5, Fig. 37), the differential valve S is controlled by a small air valve L, and a weighted lever O, together with water under pressure in the chamber P. Upon a sprinkler opening and allowing the air to escape, the weighted lever falls, releasing the air valve L, and opens the escape valve M, which governs the water chamber P, whereupon the differential valve S rises

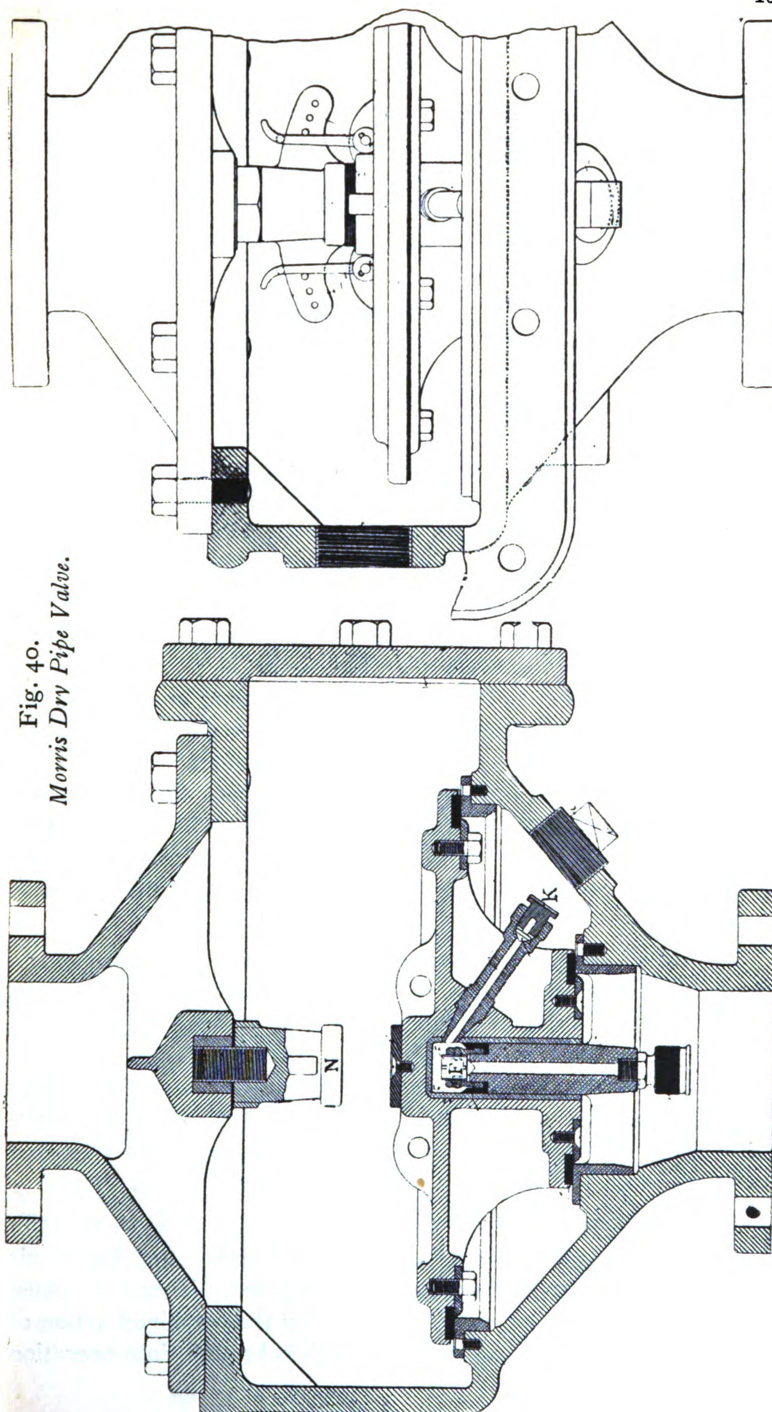


Fig. 40.
Morris Dry Pipe Valve.

and provides the necessary water way through the installation to the open sprinkler head or heads. The makers of this valve do not use the air in the installation direct on to the valve for the purpose of holding back the water, so that the air pressure in the system is unaffected by any sudden fluctuations of the water pressure.

The Titan and Hoffmann dry pipe valves (Plate 6, Figs. 38 and 39), are in many respects similar in principle to the "Grinnell." The double seated valve is, however, supported by a catch C, Fig. 39, which is attached to the valve spindle. The Titan valve is sealed with water by means of a small valve connection on the branch from the town's main, the height of the water seal being governed by setting the drain valve G at a lower level than that shown on the sketch of the Hoffmann.

The Morris dry pipe valve is shown seated in the sectional elevation (Fig. 40, p. 455); water is free to rise up to the lower seating and into the chamber of the valve F. It is, however, held in check from the installation by the air pressure acting on the top face of the valve. Upon a sprinkler opening and freeing the air in the installation, the valve lifts, and the area of the chamber being thus increased is further filled with water. Should the valve, either from its own weight or from "back flow" of water try to reseat itself, the water in the chamber will not only prevent it from doing so, but will act as a cushion to hold up the valve, as no escape of water can take place past the valves F and K.

The valve, once it is lifted, will remain fully open and fixed in the highest position, which is always up to the stop N, as the opening of the valve is sudden, and it is claimed that there is no danger of its "columning" and cutting off the supply of water to the installation. It will be noted that it is entirely dependent on the water itself. When it is desired to reseat the valve after operation, it is only necessary to slack the releasing valve K, when the valve will reseat itself from its own weight.

In the Evans (International) valve (Figs. 41 and 42, p. 458), the air and water valves are of equal area, the lower air pressure governing the larger water pressure by levers connected to the valves. The air valve is opened by the combined action of water pressure, and a ball weight, which is brought into operation

irrespective of the water pressure, when the air pressure in the installation is reduced to 9 lbs. per square inch.

Occasions may arise when it may be found necessary to temporarily cut off one supply either for repairs, testing running or other pressures, or the efficiency of a back pressure valve; subsidiary stop valves may therefore be fixed on supply pipes connected with the town's main, private reservoirs, pressure tanks and pumps (except in case of an automatic pump where the other supply is neither an elevated tank nor a pressure tank). These valves in the case of pressure tanks, wheel stop valves on town's mains or supply pipes from private reservoirs, must, however be secured open by a padlocked chain or padlocked or rivetted strap, and in case of an automatic pump by a padlocked or rivetted strap only.

Where small supply pipes to heads are fixed in isolated corners, or exposed situations, and may be affected by frost, small shut-off cocks of plug type, with fixed handles are occasionally fitted.

Pressure Gauges (Figs. 35 and 39).—Assuming that the feed pipes and general arrangements are satisfactory, it is of course necessary that some means should be provided of ascertaining that water is available at the required pressure from each source of supply, and that the valves, more particularly the back pressure valves, are performing their proper functions. Pressure gauges are therefore fixed at the most convenient and prominent position, in order to check these.

Three or more gauges are usually provided, and are fixed as shown on sketches. One above the alarm valve indicating the pressure on the installation; one below the main stop valve, but above the back pressure valves, governing the combined supplies and indicating whichever is highest of these supplies; and, where the town's main forms one of the sources of supply, one on the branch supplying the installation from the main, between the subsidiary wheel stop valve, and the town back pressure valve. As previously mentioned, in cases where a pump or injector apparatus is used, a gauge is placed on the delivery pipe on the pump or apparatus side of its back pressure valve.

Corrosion.—Trouble may be experienced from corrosion of the "heads" due to fumes or vapours arising from or in connection with the work done, or class of goods stored in a building. In such premises a frequent and careful inspection of the

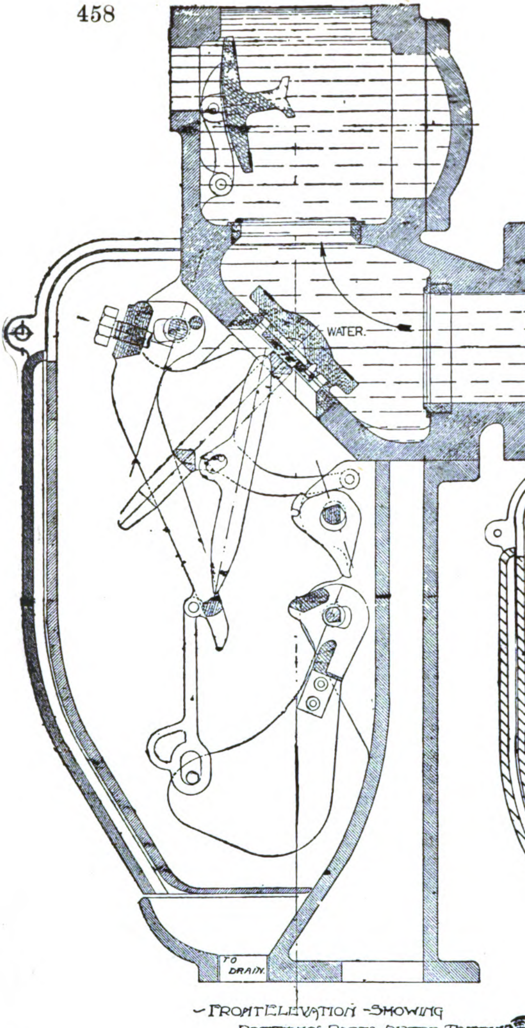


Fig. 41. *Evans' Wet Pipe Valve.*

1. Valve Body.
3. R. & L. Covers.
4. Round Plate.
6. Ball Weight.
7. Fork.
8. Hook.
9. Tumbler.
10. Strut.
11. Plate.
12. Clapper for Water Seat.
13. Clapper for Air Seat.
14. Water Seat Ring.
15. Hinge.
18. T. Pin.
19. B. Pin.
20. Outer Seat Ring.
21. Head for Ball Weight.
22. Connecting Rod.
23. Adjusting Screw.
24. Air Seat Ring.

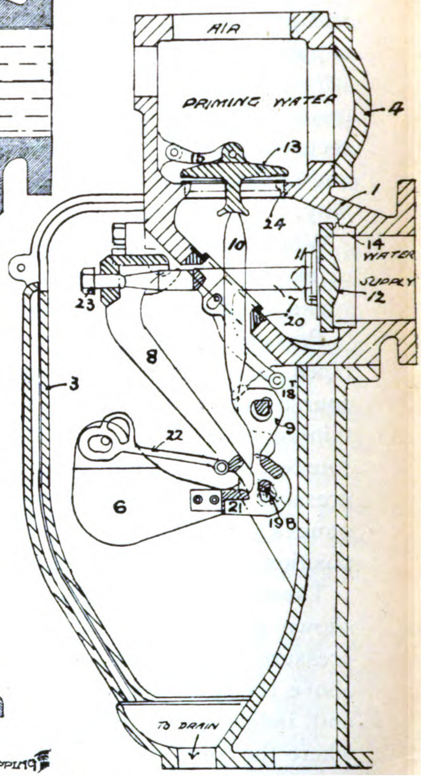


Fig. 42. *Evans' Dry Pipe Valve.*

"heads" is necessary, and it will be found advisable to occasionally change the heads, rather than run the risk of a possible failure to act when required. Various methods have been tried to overcome this trouble, but apparently with little success. There is, however, a coating compound known as "Corroproof," which is said to have been successful in generally meeting this difficulty.

Conclusion.—As already indicated, to obtain the best results an installation must be considered in conjunction with other fire-extinguishing appliances of a non-automatic character, such as steam or manual fire engines, fire plugs or hydrants, portable chemical extincteurs, portable hand pumps, buckets or cans.

Intelligent care is necessary in seeing that everything is maintained in thorough working order, by frequent tests, not only of the alarm, but also the gauges, drain and other valves and pump, whilst the running pressure should be occasionally taken, more particularly when the town's main forms one of the supplies, the results being noted for reference.

A number of spare "heads" should also be kept on the premises in case of emergency.

The advantages of having a well-equipped system of extinguishing appliances are unquestionable, and too much stress cannot be laid on the importance and advantage of dealing with fire in its incipiency. Many object lessons are afforded of what a small outbreak of fire may result in; for instance Toronto, £2,500,000 damage; Baltimore, £14,000,000; San Francisco, £60,000,000; whilst in London may be mentioned Milton Street (1889), £250,000; St. Mary Axe (1893), £300,000; Cripplegate (1897), £1,000,000; and Queen Victoria Street (1902), where enormous damage was done, and although a very lengthy list could be prepared, those mentioned will show that fires and conflagrations are factors which have to be taken into serious account in business life, and it is fair to assume in connection with the instances quoted, that had the building in which the fire started been fitted with an installation of automatic sprinklers, a different result would be recorded. Official tabulated reports do not appear to be generally kept as to results of fires in sprinklered buildings in this country; a writer, however, states "that in 1905 there were about 2,200 sprinkler installations in Great Britain, and increasing every year; the number of fires reported in sprinklered risks from their introduction up to that date was 810, of which 737 or 91 per cent. were successfully extinguished by the sprinklers, and of the remainder, 73 or 9 per cent. were classed as 'failures'—54 or 6·7 per cent. being partial failures and 19 or 2·3 per cent. total failures."

The following table obtained from the "Journal of the National Fire Protection Association," Chicago, as relating to America,

is, however, more conclusive, and shows that an approved installation is certain to control a fire under general conditions.

	Times reported.		Per cent. of number with data given.	
	1907.	1897 to 1907 inclusive.	1907.	1897 to 1907 inclusive.
Practically or entirely extinguished fire ...	594	3,563	66·96	67·06
Held fire in check ...	240	1,419	27·06	26·70
Total successful ...	834	4,982	93·92	93·76
Unsatisfactory ...	53	331	5·98	6·23
	887	5,313		

The following summary taken from the same source supplies the cause of many of the failures :—

Defective or partial equipment	...	25 per cent.
Failure due to water being shut off	...	24 ,,
Hazard too severe for control	...	11 ,,
Faulty building construction and obstruction	...	9 ,,
Exposure or conflagration ...	...	8 ,,
Inadequate or light water supply	...	7 ,,
Water supplies crippled by explosion	...	4 ,,
Defective dry valve or dry system	...	3 ,,
Water supplies crippled by frost	...	3 ,,
Unsatisfactory action of high test heads		2 ,,
Unaccounted for and miscellaneous	...	5 ,,

The author desires to express his thanks to Messrs. Mather and Platt, Limited, Witter and Son, George Mills and Company, The Hoffmann Sprinkler Company, Limited, The Sprinkler Company, Limited, and the Worthington Pump Company, for their courtesy in lending specimens, drawings, or blocks, and also his indebtedness to Mr. A. A. Thompson for his assistance in preparing the sketches.

DISCUSSION ON AUTOMATIC FIRE EXTINCTION.

MR. J. HERBERT PEARSON (Member) in proposing a vote of thanks to the author for his paper, said the subject was one that claimed the early attention of the architect, and more particularly of one concerned in the design of factories. His first consideration, however, would be to provide efficient means of escape for the workpeople in case of fire. To do this, he would allow a sufficiency of exits in suitable positions, with doors made to open outwards and staircases having fire resisting enclosures. In London, these matters were under the control of public authorities. With regard to automatic fire extinction, Mr. Pearson could not claim any special knowledge of the various forms of sprinklers referred to in the paper, but he did believe in the efficiency of such means of dealing automatically with outbreaks immediately, at the point of origin. He also favoured the use of armoured doors, constructed to close automatically across the openings in division walls, should a fire occur, and referred to their application at the Kodak Works, which were visited by the Institution last summer.

MR. CHARLES W. PETTIT (Member of Council) seconded the vote of thanks, and referred to the importance of the subject under consideration. He asked whether any automatic fire extinguishing apparatus of a chemical nature had ever been applied in out-of-the-way places.

MR. GERALD C. ALLINGHAM (Member) said he gathered that the dry-pipe system was not recommended except in cases where the wet-pipe system could not be used for some reason, such as danger of freezing; he was not sure, however, if this surmise was correct, and he would be glad if the author would make the point clear in his reply. He also asked whether any trouble was experienced through leakage of the compressed air from dry-pipe systems.

MR. J. W. SPILLER (Visitor) raised the point that according to the rules of the Fire Offices' Committee, it was stated, amongst other provisions, that all openings for ropes, belts or straps must have a sprinkler head so as to command such open-

ing, and asked the author if he would explain how sprinklers were to be fixed so as to command an opening through a floor for such belts, &c., considering that to catch the heat, sprinklers must be fixed on the ceiling above the opening, where sprinklers were already fixed to protect a room. This at once raised the question as to whether fixing any extra sprinkler over such an opening at the ceiling above would not bring two sprinkler heads too close together, *i.e.*, so close that the water from one head, should it open, would wash the other head and prevent it from opening. In other words, it would appear that the sprinkler heads at the ceiling in the room above would provide adequate protection for an opening in the floor below.

MR. J. E. O'BRIEN (Member) considered that the paper would be regarded as valuable since it dealt with one of those side issues of engineering to become acquainted with the features of which very few opportunities were afforded. The accompanying illustrations were admirably prepared and very complete. He believed that during recent years the sprinkler system had made great headway. A large number of sprinklers had been installed in the factories in and around Nottingham, and as an auxiliary to the protection of a building from fire were becoming more and more extensively applied.

MR. B. E. DUNBAR KILBURN (Member) expressed appreciation of the mass of useful matter contained in the paper, but directed attention to one point on which he thought the author might with advantage give some information for the benefit of those who, like himself, had not a practical knowledge of the apparatus considered. He desired to know what arrangements were customary for testing the sprinklers, since their construction would rather lead one to imagine that if left for any length of time they might be liable to fail when occasion arose, though on the other hand, experience might have proved that testing was unnecessary, the sprinklers being safely relied on to come into operation when required. In the event of testing being necessary it would be interesting to know how it was carried out, as obviously it was not possible to allow the sprinklers to come into effective operation, since damage would obviously result.

MR. A. W. MARSHALL (Member) said that Mr. Kilburn had raised an important point when urging the necessity for testing sprinklers to ascertain if they were in working order ; by cor-

rosion they might remain for many years inactive, and the valves become fixed. He remembered an electrically operated sprinkler which was introduced some years ago. The valve was held by a catch released by the pull of an electromagnet. A thermostat was used to complete the circuit. It consisted of a strip of two metals having unequal rates of expansion. If the temperature of the air reached a certain degree the tongue of the strip moved over a gap and made contact with a stud; electric current then passed through the circuit from a battery and excited the sprinkler magnets, which, pulling back the catches released the valves. It seemed to him that such a method gave facilities for testing the valves; the pipes could be first drained free of water, and he would ask the author if he knew the reasons which had prevented this method from coming into use. Electrically operated sprinklers were mentioned in the paper, but no examples had been described.

MR. JAS. SHEPPARD (Visitor), in response to a request from the Chairman for some remarks, said that to obtain the full advantage which a standard sprinkler installation was calculated to give, it was essential that the sprinklered building should be planned, constructed, and used in such a manner as to secure the effective separate action of every sprinkler head. Neglect of such precautions was responsible for a considerable number of sprinkler failures.

Concealed spaces in partitions, between ceilings and floors, in roofs, behind walls, and other finishings, pipe casings, and all similar arrangements, should be avoided. Cupboards and workmen's lockers were serious danger points, and should be formed entirely of expanded metal or at least have the top constructed of that material. Large undivided floor areas tended to possible failure. Waves of heat from a small fire in a warm factory had distributed themselves along the ceiling, and opened such a large number of sprinkler heads as to render all of them ineffective. This danger might be guarded against by slight screens of incombustible material fixed so as to project about 18 inches below the ceiling, forming pockets to concentrate heat and prevent its too rapid diffusion, at the same time hastening the opening of sprinklers over the seat of the fire. Such an arrangement might necessitate the provision of a few more sprinkler heads, which would be a further advantage.

Belt or rope races, and vertical shafts for main drives had proved especially dangerous. Such places, in addition to being properly sprinklered, should be securely isolated from the main portion of the building. Stairs and lift wells should be enclosed, and openings through floors should be avoided or specially protected. Spouts or trunks through floors or walls also needed special treatment. The stacking of goods within 2 feet of the sprinkler heads was very objectionable, and the use of electric power in sprinklered mills necessitated special precautions.

During 1907 there were at least twelve fires in sprinklered cotton mills in Lancashire, resulting in losses of from about £2,000 to £9,000 each. In some instances the sprinklers may have assisted the fire brigades in preventing more serious loss, and some of these unsatisfactory fires could not be charged directly to failure of the sprinkler installation, but they all pointed to the necessity for constant, conscientious, and intelligent supervision and maintenance before, during and after a fire, which it was very difficult to secure. The provision of efficient first aid fire extinguishing appliances and fire hydrants, was necessary in all cases, in addition to the sprinkler installation. Drenchers operated by the manual opening of a valve for the protection of roofs, windows and other openings, formed an important branch of a sprinkler equipment, and were necessary in the case of sprinklered buildings exposed to external risks. He heartily thanked Mr. Bullock for his interesting paper, so fully illustrated, which could not fail to be of value, not only to engineers, but also to fire office surveyors and officials.

MR. ALEX. J. SIMPSON (Member) asked the author whether an accumulation of dust of an insulating nature, such as wood-dust, affected the efficiency of the fusible alloy used in the sprinkler. Was it not desirable to keep the heads as clean as possible? When placed in inaccessible positions there was a risk of their being overlooked and neglected, and failure resulting. As to the question of cost, he had in mind a factory where the installation had cost £1·8 per sprinkler head. This price included water companies' charges for running a 4 inch branch main from the street to the valves, a distance of about 20 feet. The installation was of the alternative wet and dry system, and the total area protected was approximately 6,160 square feet.

MR. J. W. JOHNSTON (Member), referring to the provision necessary in the case of dust or refuse exhaust trunks, enquired whether it was not good practice to place a sprinkler at the head of the trunk in addition to one on the delivery side of the fan. He also asked, with reference to water supply, what sizes of waste pipes were required for various sizes of installations, and, in regard to pumps, what was the maximum plunger speed allowed in connection with sprinkler installations.

MR. L. F. DE PEYRECAVE (Member) after thanking the author for the comprehensive character of the paper, thought the members would be very glad to know approximately how much an efficient fire extinguishing installation might be expected to cost say per cubic foot of building or per square foot of floor space, or in any other convenient symbols.

THE CHAIRMAN, in closing the discussion, congratulated Mr. Bullock on the extremely interesting paper which was compiled in such a thorough manner and was so well illustrated in the text and by the collection of specimens, &c., exhibited. Mr. Bullock had laid before the Institution information of the greatest value to all those concerned in large factories and manufacturing works. There were, however, a few questions that he would like to ask for further information. First, whether any trouble arose from certain kinds of water causing the valves to stick, and whether the Fire Insurance Companies took into account the analyses of the waters in considering the usefulness of the sprinklers; secondly, what was the approximate water consumption per sprinkler under the usual pressure recommended by the manufacturer; and thirdly, how was the periodical testing of the sprinklers carried out without causing much internal damage. Being a sceptic of most automatic appliances, he was sorry that hydrants and their maintenance had not been mentioned, even in a comparative way. With an efficiently trained corps of local firemen, good work had often been done with such apparatus. He objected to the phrase of "fireproof," and would prefer to see "fire resisting" adopted, as, after all the extensive conflagrations that had occurred in recent years, the term "fireproof" had been completely disproved.

The vote of thanks having been put to the meeting, was carried by acclamation, and Mr. Bullock replied.

BIRMINGHAM LOCAL SECTION.

The Sixth Meeting of the First Session of the Birmingham Local Section was held at the Headquarters of the Electrical Engineers Volunteers (Birmingham Detachment) on Monday, 16th March, 1908.

Mr. F. S. Pilling (Vice-Chairman of the Institution) took the chair at 8 p.m., and there was an attendance of 13. After the minutes of the previous meeting had been read, confirmed, and signed, Mr. Ellis read a letter received from the Secretary of the Institution, intimating the Council's unanimous sanction of the formation of a local section in Birmingham, and took the opportunity of stating that it had not been due to his (Mr. Ellis') efforts alone, but that he had received much assistance from other members of the Institution resident in the district, whom he now wished to sincerely thank.

The election of officers then took place, with the following result :—

Chairman: Fred S. Pilling, M.I.Mech.E.
Vice-Chairman: E. A. Dowson, A.M.I.Mech.E.

Council:

E. E. Jeavons.	A. J. Rowledge, A.M.I.Mech.E.
H. T. Poole.	L. G. Stanger-Leathes, A.I.E.E.
T. H. Relton, A.M.I.E.E.	E. G. S. Vaughan.

Hon. Auditor: J. M. Summers.
Hon. Secretary: R. B. Askquith Ellis.

The Chairman then called upon the Hon. Secretary to read Mr. G. T. Bullock's paper on "Automatic Fire Extinction as Applied to Factories."

The discussion upon it was opened by Mr. T. H. Relton, who, in moving a vote of thanks to the Author, considered the paper was one of the most important contributions of the Session, and suggested that an electrically-operated equipment would prove most satisfactory in practice. Mr. Vaughan (Member), who seconded the motion, spoke of the advantages of the use of ferro-concrete in preventing the spreading of an outbreak. Mr. Murgatroyd (visitor) stated, in reply to several speakers, that the sprinklers as described by the Author, provided the most effective methods of dealing with outbreaks of fire, and with the aid of a lighted match illustrated the process of the working of a

sprinkler. Messrs. Boggust, Maundrell, Bowker and Knipe also joined in the discussion.

The Chairman, in putting the resolution, which was carried unanimously, expressed the view that with insurance premiums costing only about 3s. 6d. per cent. per annum, the expense of installing a sprinkler system was not justified, even allowing for a reduction of premium which would be conceded where sprinklers were introduced.

Mr. A. J. Rowledge (Member), who was not present, enquired whether fireproof materials of construction were very enduring, or deteriorated in course of time.

With the announcement of the next meeting on Thursday, 9th April, when Mr. G. H. Hughes' paper on the "Purification of Water" would be read, the proceedings terminated.

MR. GEO. T. BULLOCK (Vice-Chairman) in replying to the discussion, expressed his acknowledgments of the kind remarks made by Mr. Pearson and Mr. Pettit, the proposer and seconder of the vote of thanks, and his appreciation of the manner in which his paper had been received. He fully endorsed Mr. Pearson's views, and was quite sure it would be to the architect's advantage to give the subject of automatic fire extinction careful consideration in connection with factory premises. The type of chemical apparatus referred to by Mr. Pettit had been used, but had not yet received official recognition by the Fire offices; he (Mr. Bullock) had recently been asked to inspect such an apparatus, but was not prepared on the present occasion to express an opinion upon it.

Mr. Allingham was correct in assuming that the dry pipe system was only to be recommended in buildings where frost was likely to have effect. As regards air leakage, very little trouble need now be apprehended from that source, provided that the installing of the system had been well carried out. The question raised by Mr. Spiller with reference to openings for belts, &c., was an interesting one, but the author did not think there was so much difficulty in it as appeared at first sight. Each case

would require consideration and decision according to circumstances. He felt, however, that Mr. Spiller, with his great experience, would have little trouble in complying with the requirements laid down.

In connection with Mr. O'Brien's remarks he might say that sprinkler installations had long been in use in the Nottingham district, and that their number was increasing, a fact probably partly due to the good water pressure available. Replying to Mr. Dunbar Kilburn, he said it was necessary to frequently test the efficiency of an installation. The alarm valve and gong must be tested weekly, for which a half-inch test cock was provided, as mentioned at page 453 of the paper. A running test might also be frequently made by opening the 2 inch drain pipe (see paper, page 453) in each case noting the reading of the pressure gauges both before and after testing, when, by a simple calculation (the height of the highest sprinkler being known) it would be easily ascertained whether the required pressure (see paper, pages 439-441) was being obtained. When carrying out the latter test it was advisable to shut off the cock governing the alarm so as to avoid unnecessary disturbance in the minds of the workpeople. Tests might also be made with the various water supplies separately, and, as indicated in the paper, inspections of the installation as a whole were essential. It was also usual for the Insurance Companies to make a thorough inspection and test at stated periods.

Mr. Marshall's observations on the electrically-operated sprinkler were interesting, but the author had no doubt that the experts acting on behalf of the Fire offices had carefully considered the advantages claimed for such a type before giving an adverse opinion. He would, however, state that if it was necessary for the pipes to be first drained free of water before testing, that in itself would be one of the first points raised against the adoption of such a system. He thanked Mr. Sheppard for the remarks he had kindly made, which would form a valuable supplement to the paper. Mr. Simpson desired information as to dust affecting the operation of the fusible alloy used in the sprinkler. An ordinary coating of dust on a sprinkler had not been found to materially affect its prompt opening when required; it was, however, desirable that the "heads"

should be frequently examined, and dust or other deposits removed. In some classes of factories the Fire office would probably insert a warranty in the insurance policy requiring this to be done.

In reply to Mr. Johnston, the author stated that it would depend upon the size, shape, and position of the trunk whether a sprinkler should be placed at the head of the trunk, in addition to one on the delivery side of the fan. The minimum size of a waste pipe for all installations was now 2 inches. The plunger speed in calculating the capacity of a pump must not exceed 150 feet a minute for each plunger. Replying to Mr. de Peyrecave's enquiry it was difficult to indicate, even approximately, the cost of erecting an installation, as everything practically depended on the class or type of water supply available, but for an ordinary installation having town's main and gravity tank supply, the cost might be estimated at from 16s. to 20s. per sprinkler. He thanked the Chairman for his appreciative remarks, and in reply to his questions stated that the Fire offices had to depend on their official tests of the installations to ascertain whether any trouble due to the quality of water available was likely to arise. The approximate water consumption per sprinkler was as follows:—

Pressure at sprinkler in lbs. per sq. inch, water flowing	2½	5	10	15	20	30	40	50	75	100
Discharge in gallons per minute (approximate)	8½	12	17½	21½	25	30	35	40	50	60

The periodical testing consisted principally of ascertaining that water was available from the various sources at the required pressure, by running it through the 2 inch waste pipe, which was drained to a convenient outlet. He expressed the hope that Mr. Durham's views as to automatic appliances as relating to fire extinction would, after all that had been adduced that evening, be more favourable to them. As indicated in the paper, the author did not intend in any way to detract from the usefulness of non-automatic appliances, when in the hands of efficiently trained brigades. He quite agreed with the remark appertaining to the phrase "fireproof." It was, however, very difficult to convey the full meaning of "fire resisting" to the ordinary layman, who still preferred the older but unsatisfactory term.

MR. BULLOCK has communicated the following in reply to the discussion at Birmingham :—" I have to thank the members of the Birmingham Local Section for their appreciation of my paper, and with regard to Mr. Relton's suggestion as to electrically operated equipment, would refer him to the reply to Mr. Marshall on the same point. I am in agreement with Mr. Mr. Vaughan's views, but they also apply to practically all materials having fire-resisting qualities. It must not be overlooked, however, that one of the chief points to be regarded is the kind of work to be carried on, or the class of goods to be stored in the building under consideration. If in any way of a hazardous nature there may be disastrous results, irrespective of the system of construction of the premises. In this connection it would be interesting to know what class of materials of construction Mr. Rowledge had in mind when putting his question as to their endurance. Adverting to Mr. Pilling's remarks, it must be borne in mind that the advantages of fire protection cannot always be gauged by mere £ s. d. There are many firms who have had their premises fitted with Automatic sprinkler installations and also provided other systems of fire protection without considering the actual amount saved in insurance premiums, but rather keeping well in view the probable dislocation of their trade or possible ruination of their business which might result from a conflagration. I believe that a few years ago, some factories were insured at rates not exceeding that mentioned by Mr. Pilling, and a discount of, from 40 to 50 per cent., which was allowed on account of fire protection, fully satisfied the owners. The proportionate number of factories carrying much higher rates for insurance than that quoted is very large, and with discounts varying from 20 to 50 per cent., according to the protection provided, is undoubtedly another indication that the subject is worthy of the consideration, not only of engineers and architects, but also of their prospective clients.

NEW GENERAL POST OFFICE BUILDINGS.

The Twelfth Visit of the Twenty-seventh Session took place on Saturday afternoon, 14th March, 1908, when, by permission of the Postmaster-General, the Rt. Hon. Sydney Buxton, M.P., the New General Post Office Buildings, in course of erection in Newgate Street, were inspected, the attendance being 73.

Through the courtesy of the Builders, Messrs. Holloway Bros. (London) Ltd., special facilities were extended in connection with the visit; the constructional drawings were exhibited and explained to the members before they were shown round, under the guidance of the Manager of the Engineering and Ferro-Concrete Departments of Messrs. Holloway Bros., Mr. T. A. Watson (Member of the Institution), Mr. Chapman and Mr. Gerrad (representing Mr. L. Mouchel), and Mr. Willett.

The members' acknowledgments of the excellent arrangements which had been made for their reception were expressed by Mr. Geo. T. Bullock (Vice-Chairman) at the conclusion of the visit, and Mr. Watson replied.

The following particulars of the work have been kindly supplied by the Builders:—

The New General Post Office Buildings consist of two blocks:—(1) the Public Office (210 feet long by 54 feet wide by 80 feet high), and (2) the Sorting Office blocks (312 feet long by 212 feet wide by 75 feet high), with a loading yard (201 feet long by 60 feet wide) between. Both blocks have a lower ground and a basement floor, covering the whole site, including the loading yard, under which they are connected. The basement level is 25 feet below the pavement level, and the surrounding earth is retained in position by an 8 inch thick ferro-concrete wall, strengthened with vertical buttresses 8 inches wide by 14 inches deep on inside of same, the buttresses being fixed in position at their bottom, middle and top by horizontal beams, which in turn transmit the thrust from earth pressure on to the main floor beams and columns of the building. The buildings are built entirely in ferro-concrete on the Hennibique system (with the exception of the elevations fronting Newgate Street and King Edward Street, and the two end elevations of the Public Office block, which are to be in stone), and form one huge monolith from

basement to roof. The outer walls of the two blocks vary in thickness from 6 inches to 12 inches, and are carried at each floor level by ferro-concrete beams on stancheons, the latter being spaced 35 feet 6 inches to 40 feet apart. The floors, $3\frac{1}{2}$ inches thick generally, are supported on secondary beams 35 feet span 16 inches deep by 8 inches wide, spaced 5 to 6 feet apart, which in turn are supported by main arch beams, 35 to 40 feet long, 5 feet deep at haunches, and 2 feet 6 inches deep at centre by 10 inches wide, spaced at 35 feet centres, and rigidly attached to the main columns by means of the reinforcing rods overlapping into the contiguous beam and passing between the column rods. The whole weight of the buildings is thus distributed over the columns, and from them to the slabs resting on, for the most part, gravel foundation. A bridge connects the second floor of the Public Office to the Sorting Office block in one span of 57 feet. Other special features of construction are two tunnels under King Edward Street, 25 feet below the ground, approximately 50 feet long and 7 feet wide by 10 feet high, the cnimney 130 feet high, and the cantilever beams (projecting 12 feet 6 inches) at first floor level, carrying the east wall of the sorting office block three stories high.

AUTOMATIC IES.

PLATE 1.

Longitudinal Section of a Factory sho nnell Automatic Sprinkler.

REFERENCES.

A. Main Supply fromTown's Main.
A'. Back Pressure Valve.
B. Main Supply from Fire Pump.
B'. Back Pressure Valve.
C. Down Pipe from Tank.
C'. Back Pressure Valve.
D. Tank.
D'. Tank Drain and Overflow.
E. Tank Feed.
E'. Stop Cock on Tank Feed.
F. Ball Tap.
G. Indicator Board.
H. Quadruple Acting Fire Pump.
K. StopValve on Pump Connections.
M. Foot Valve.
N. Strainer.
P. Pump Suction Piping.
R. Alarm Valve.
S. Main Installation Stop Valve.
T. Combined Drain and Test Cock.
U. Pressure Gauges.
V. Alarm Gong.
W. Armoured Fire-proof Doors.
Y. Simplex Chemical Extincteur.
Z. Sprinkler in Action.

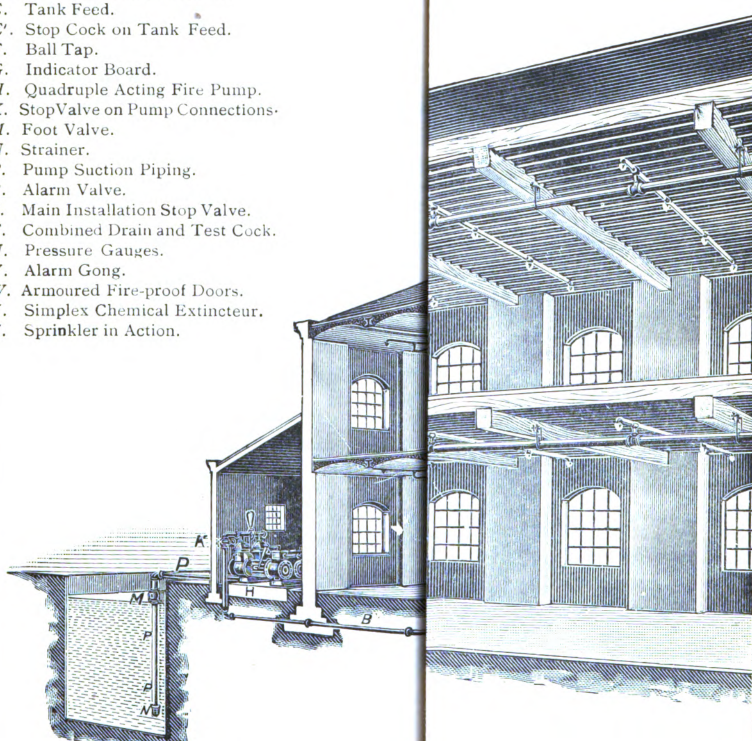
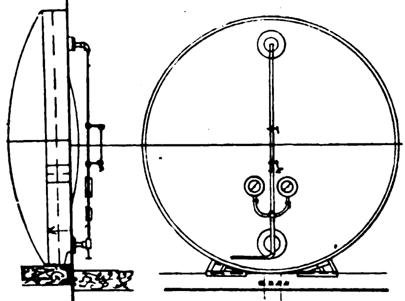


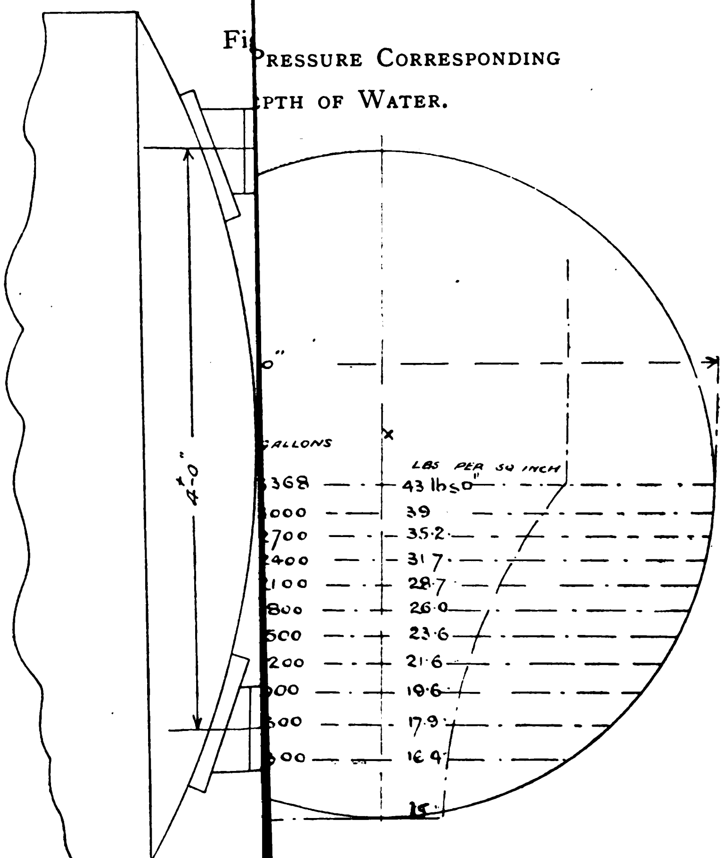
Fig. 29.

Pressure Tank.



Fi[g.] [P]ressure Corresponding

[De]pth of Water.



LIED TO FACTOR

PLATE 3.

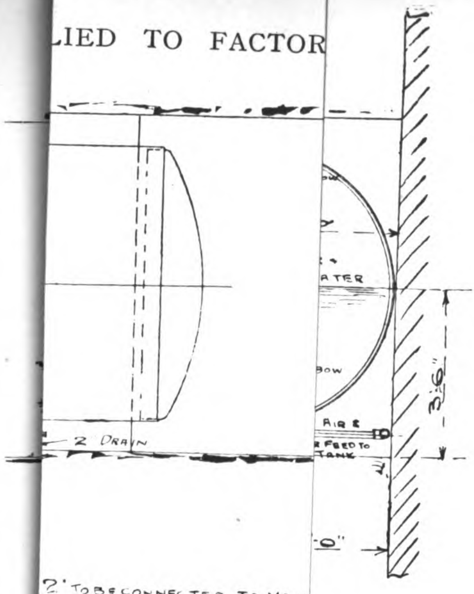
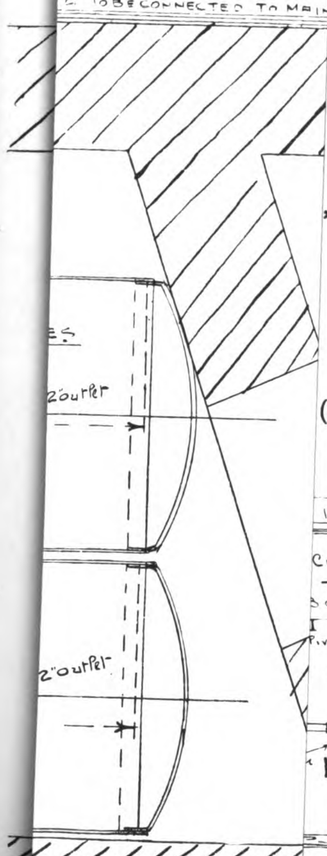


Fig. 30.

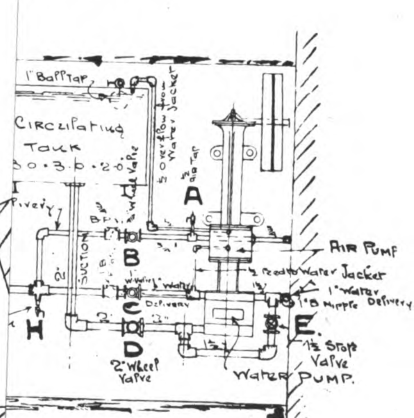
Pressure Tank.

AND CONNECTIONS AT THE

, ROUEN.



(see Plan).



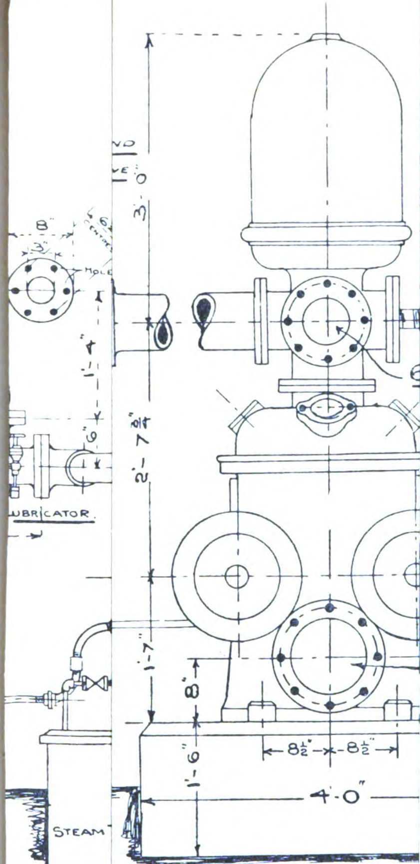
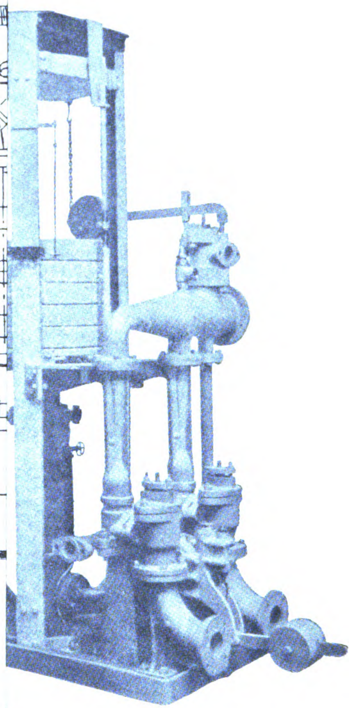
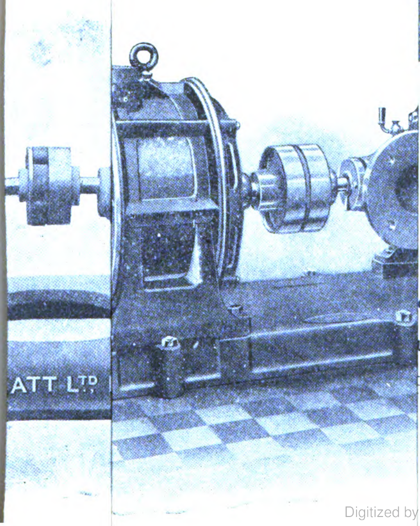


Fig. 34.
utomatic
Iydraulic
Injector
pparatus.

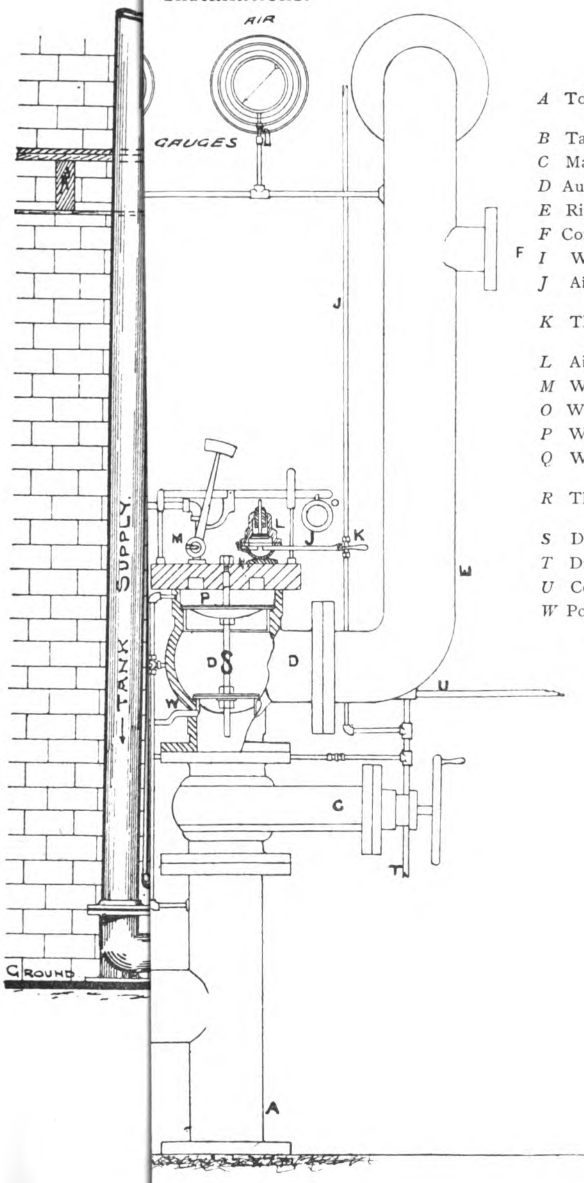




ig. 33.
ectrical
urbine
Pump.

PLATE 5.

Fig. 37.
tic Water Valve for Dry Pipe
Installations.



A Town's water or pump connection.

B Tank connection.

C Main stop valve.

D Automatic water and air valve

E Rising main to installation.

F Connection for washout valve.

I Water level indicator.

J Air pipe from installation to air valve *L*.

K Three-way cock for testing automatic air valve.

L Air valve.

M Water escape valve.

O Weight on lever.

P Water chamber.

Q Water pressure-pipe to chamber *P*.

R Three-way cock for converting valve into wet system.

S Differential valve.

T Drain pipe.

U Connection to air pump.

W Port to allow water to pass to alarm gong.

Part 9. **JUNE, 1908.** **Vol. XVIII.**

The Junior Institution of Engineers.

(Incorporated.)

President - - M. GUSTAVE CANET, M.INST.C.E.,
Past-President Institution of Civil Engineers of France.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

5th June, 1908.

ANNOUNCEMENTS.

THURSDAY EVENING, 11th June, at 6.30 p.m. Visit: Messrs. Taylor, Walker and Co.'s Brewery, Church Row, Limehouse, near Limehouse Station, Great Eastern Railway. Admission on production of Badge of Membership.

SATURDAY, 27th June to 11th July. Summer Meeting in France, the party assembling in Paris on Saturday evening, 27th June.

LECTURES ON "RECENT IMPROVEMENTS IN ELECTRIC LIGHTING." A course of Three Lectures is to be given by Professor JOHN T. MORRIS, M.I.E.E. *(Member of the Institution)*, at the East London College, Mile End Road, E., on Mondays, 15th, 22nd and 29th June, from 8 to 9.30 p.m. Sir W. H. White, K.C.B. *(Past-President)* takes the chair at the first Lecture. Members of the Institution are invited to attend free of charge. **Tickets may be obtained on application to the Registrar at the College.**

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

LASSEN, JENS JACOB; Messrs. Lassen and Hjort, 52 Queen Victoria Street, London, E.C.

MANUÉLIDÈS, THEMISLOCLES ATHANASIA; North Metropolitan Electric Power Supply Company, Tramway Avenue, Edmonton.

STUBBS, ARTHUR; 14 Osterley Gardens, Thornbury Road, Osterley Park, Isleworth, W.

Proposed for election to the class of "Associate."

HARPER, HAROLD W.; Messrs. J. Westwood and Co., Napier Yard, Millwall, E.

MILBOURN, DACRE VIDLER; Messrs. T. J. Hosking and Co., Bermondsey, S.E.

Changes of Address.

ADAMS, P. W., Car and General Insurance Corporation, Ltd., 71 George Street, Edinburgh.

ANDERSON, W. T., 298 Hyde Road, Gorton, Manchester.

BOOTHROYD, A. W., 9 The Circus, Greenwich.

DICKSON, A. J., 19 Keswick Road, St. Helens, Lancs.

EVANS, F. D., P.W.D., Selangor, Federated Malay States.

FAWKES, A. W., 20 Buckingham Avenue, Montreal, Quebec, Canada.

FORD, F. G., 56 Ingleby Road, Ilford.

GREGORY, V. H., 37 Park Road, Chiswick, W.

HULME, C. T.; High Street, Kenilworth, Warwickshire.

KEEVILL, R. G., 66 Southdean Gardens, Wimbledon Park Road, S.W.

RAMASWAMIENGAR, M. S., Sub-overseer, District Local Board, Karwar, N. Canara, Bombay Presidency, India.

ROBERTS, E. D., c/o Mrs. Heggins, "Frascati," Osterley Park Road, Southall, Middlesex.

VERNIER, C., 20 Ripon Gardens, Jesmond, Newcastle-on-Tyne.

Appointments.

228. Member, age 21, desires engagement at home or abroad, in an electrical or mechanical engineer's drawing office, or as assistant in engineer's office. Seven years' shop and drawing office experience.

229. Member, age 36, with thorough practical and theoretical training, at present holding responsible position with leading Gas Engine and Suction Gas Plant Makers, seeks situation or partnership in or near London.

230. Member, age 30, general mechanical engineer, with five-and-a-half years' experience of business management, two years drawing office, five years shops, desires responsible appointment. Highest references.

PERSONAL NOTES.

G. R. EARDLEY-WILMOT is now in the Chief Locomotive Superintendent's Drawing Office, C.S.A. Railway, Pretoria, Transvaal.

R. B. A. ELLIS has been duly entered in the Territorial Army, his official position being Company Sergt.-Major, Wireless Company, R.E. Telegraph Companies, Southern Division.

J. W. ENGLISH has become First Director of the Mining Department of the "Steana Romana," the largest Roumanian Petroleum Company. Address, Strada Surorilor, 11BES, Bucarest, Roumania.

GEORGE EVETTS has been elected an Associate Member of the Institution of Civil Engineers. In the qualifying examination he was bracketed with another candidate top of the list and so obtained "special distinction."

ARTHUR FINBOW sails for Hong Kong on 6th June by P. & O. S. "Syria," having obtained the appointment No. 110, which was announced in the last number of *The Journal.*

REG. C. GOODMAN has joined the s.s. "Moravian," of the Aberdeen West Star Line, as fourth engineer, and expects to be back from his first voyage in August.

F. P. HARLEY is now Manager to the London Sherardizing Company, Ltd., 6 Great Winchester Street, E.C.

F. J. HILL has joined the staff of Messrs. Thos. Evans and Sons, Ltd., as Draughtsman.

HENRY A. JONES is now with Messrs. Homan and Rogers, of 17 Gracechurch Street, E.C. (*1026 Avenue.*)

JULIAN JULIAN has been appointed Borough Engineer and Surveyor to the Borough of Cambridge.

B. A. KUPFERBERG writes from the Bhuntia Chang Tea Company's Estate at Darrang, Assam, India, where he has obtained an appointment as Assistant Engineer.

W. E. LILLY has contributed to "The Times Engineering Supplement" an article on "The Education of Engineers in Ireland."

ALFRED E. LOACH (*Member*) has just been successful in passing the Professional Associateship examination of the Surveyors' Institution. He has recently passed the examination for the Testamur of the Incorporated Association of Municipal and County Engineers, and the full-membership examination of the Institute of Sanitary Engineers, as an Associate.

CHAS. J. MCNAUGHT has been appointed General Manager to Messrs. Marryat and Place, Shepherd's Bush, W. Private address, 31 Askew Crescent, Shepherd's Bush, W.

F. A. NECK has returned to his duties in Sierra Leone. Address, c/o General Manager, Government Railways.

J. E. O'BRIEN sails for Sydney, New South Wales, on 2nd July, having entered into a business partnership there.

R. S. RUST is now serving as Engineer on the British India Steamer "Lama," between Calcutta and Rangoon. Address, c/o B. I., Engineers' Club, 1 Vansittart Row, Calcutta.

H. V. STEPHENSON has been elected an Associate Member of the Institution of Mechanical Engineers.

CYRIL STODDART has been elected an Associate Member ot the Institution of Civil Engineers.

WILLIAM THORPE has obtained an appointment as Draughtsman with Messrs. Samuel Cutler and Sons, Providence Ironworks, Millwall.

AUGUSTUS G. TURNER has obtained an appointment as Assistant Engineer to Messrs. Geo. Wimpey and Co., and is at present engaged on a contract for the London County Council Tramways from Hammersmith to Harlesden.

E. G. S. VAUGHAN sails on 13th June for Lagos, having been appointed Assistant Engineer in the Public Works Department of Southern Nigeria. Address, c/o Director of Public Works, Lagos.

W. C. WEDEKIND has been elected a Member of the Institution of Mechanical Engineers, The Iron and Steel Institute, and the Society of Engineers.

DOUGLAS YOUNG has gone into the Drawing Office of Messrs. H. Young and Co., Nine Elms Ironworks, Nine Elms, S.W.

CORRESPONDENCE.

THE DURHAM BURSARY.

MR. F. R. SWAIN (Member) writes:—By means of the Durham Bursary we have Mrs. Durham in her own gracious manner urging forward interest in the training of the youthful engineer.

Why should not the Junior Institution bestir itself as an Institution and do something for him too?

Mr. Parsons' comments in the May *Journal* on young men's early struggles are no doubt very moving, and are likewise true, but there are many others who want help in another direction.

The general question of the education and training of young engineers is a matter upon which the Junior Institution might usefully focus its attention. Interest in this subject is ever fresh, but nothing like a reasoned conclusion seems to be reached.

It is true there are "courses of engineering" at the various colleges. But are these the one thing needed? There is no consensus of opinion that they are. Recent articles in the "Engineer" have shown that even among manufacturing firms of high standing there is great diversity of practice on the subject of the training to be given to the Engineer in embryo.

The Junior Institution is in close touch with this matter and is more fitted to deal with it than any other body. Its members have their experiences and their difficulties fresh in their minds. Most of the people who handle this question have rather passed out of touch with it. In the aggregate there is an enormous mass of experience among the members, which, if sifted out, should enable very clear and definite ideas on the subject to be laid down.

Let the Institution collate the ideas of those so well fitted to judge of the merits and particularly the shortcomings of the present era. It would then be in a position to promulgate a "standard of training" for the various branches of the profession. Publish this widely, and it could not fail to carry great weight when the standing of the Junior Institution of Engineers is considered; whenever possible influence firms and colleges until they are prepared to give that training definitely ascertained to be required.

There is also another point from which this question may be viewed. Many parents of sons who want to become engineers are unconnected with the profession and quite ignorant of what to do for the best. What they want is sound advice.

If the Institution would prepare itself to give the advice, the parents could insist on getting the right article in the way of training.

THE TESTING OF GAS ENGINES.

MR. STANLEY M. HILLS (Member) writes:—I have read with great interest Mr. Whalley's paper on the testing of gas engines and note that in the discussion a question was asked about the Walker fan dynamometer. In 1906, in conjunction with two of my colleagues, Mr. T. Germann (Member) and Mr. A. G. Savill, I made an exhaustive series of tests on one of these dynamometers. The object of the experiments was to obtain calibration curves for the brake, and tests were carried out on Dr. Drysdale's test bed. (For description see "Engineering," 24th November, 1905.)

I found that the results were considerably affected by:—

(1) One of the observers standing in, or near the line of draught of the fan.

(2) One of the doors of the laboratory being open or shut.

(3) Enclosing the fan in a large packing case, thus showing that the results vary with the size of the room in which the fan is being run.

Further, the fan creates a very strong draught, and it is impossible when using it for motor (electric) testing to obtain a temperature test, owing to the cooling effect of the draught. The cooling effect will cause the efficiency obtained to be higher in value than it would be if obtained by a Prony brake test, or other method, where the temperature was not reduced by an artificial draught. The draught created would have a similar effect on a petrol motor, and therefore, in my opinion, the brake fails because it is not possible to make tests with it under practical working conditions.

AERIAL NAVIGATION.

MR. CECIL G. YOUNG writes on S.S. "Ganges," nearing Aden :—Since leaving England at the end of last October in this ship belonging to the Mercantile Steamship Co., Ltd., of London, we have visited Hong Kong, Calcutta, Bombay, Moulmein, Rangoon and Colombo (for coal), and are now nearing Aden, also for coal, being now bound for Fiume. All this time I have had *The Journal* forwarded to me, and though necessarily a month late I quite look forward to receiving it.

I was specially interested in the March number, containing Mr. Chatley's paper on "Aerial Navigation," and the discussion which followed it ; it has served to awaken my keen interest in the subject. There are one or two questions which I should like to ask. Firstly : What is the form of the waves in the stream lines caused by the aerial disturbance, and secondly : Do these waves explain the peculiar phenomenon of a seagull soaring apparently dead against the wind. I have noticed that while we have been steaming through a good stiff gale the seagulls will keep up with the ship without moving their wings relatively to their bodies, merely swaying from side to side as if to keep their balance. They do not fly for a while, and then soar like the swallows, but keep on almost motionless for quite a long time.

MR. CHATLEY replies as follows:—Several interesting points are raised in Mr. Young's letter. As regards the forms of the stream lines, these have a very definite relation to the forces acting on the moving surface, and if the exact forms in any case could be predicted, the subject of aërodynamics would be greatly advanced. Unfortunately, only in a few cases, and then under certain limitations, can these forms be found. The mathematical methods employed will be found in Professor Lamb's "Hydrodynamics," and also in the article "Hydromechanics" in the Encyclopædia Britannica, 9th Edition. Mr. Lanchester's book, "Aërodynamics," also deals with this subject. Dr. Hele-Shaw's papers to the British Association, the Institution of Naval Architects, and to the Junior Institution, show how the lines may be determined empirically by injecting colouring matter into flowing water, and he has been able thereby to strikingly corroborate the mathematical analysis, and investigate other cases not amenable to such analysis.

The assumptions involved, however, in both the mathematical analysis and its experimental corroboration, are not wholly true in the case of the sustaining surfaces of aerial machines, since the air is compressible, has a perceptible viscosity, and the velocities attained are above the critical values at which completely continuous flow ceases. By means of small flaps attached to an aëroplane or by the smoke jet method invented by Professor Marey and adopted by Dr. Hele-Shaw, it may be shown that at the rear of the surface there is a space in which eddies are formed and the pressure is less than atmospheric. This space will be bounded by a surface (or in section, a line) of discontinuity. The correct determination of this forms one of the most difficult problems we have to deal with. I append two sketches (*see over*), showing (1) The stream lines about an infinitely broad and thin lamina in a perfect fluid (roughly sketched from Lamb's "Hydrodynamics"); (2) Conjectural form of stream lines about a real lamina moving above the critical speed through a real fluid.

With reference to Mr. Young's question, "Do these waves explain the peculiar phenomenon of a seagull soaring apparently dead against the wind?" There are three suggested explanations of this well-attested phenomenon:—(1) Aspiration; (2) Velocity difference in strata of air; (3) Periodic variation in the velocity of the wind.

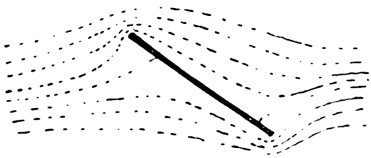


Fig. 1.

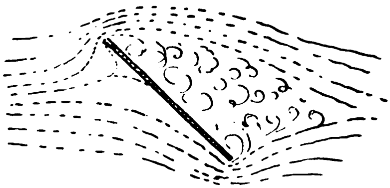


Fig. 2.

The first hypothesis is that the form of the section of the wing is such that when presented to the wind in a particular direction, the stream lines are deflected in such a manner on to the under side of the aërocurve that there is a forward acting thrust, whose vertical component balances the weight and the horizontal component provides the forward push (and therefore exceeds the "drift" or total resistance of the moving body). This involves a mechanical paradox for which I am not prepared to plead. It seems impossible, but having regard to the extraordinary manner in which the air does behave, I will not say that it is not the true explanation. A third sketch (for which I accept no responsibility) is appended to indicate the possible stream lines. (*See below.*)

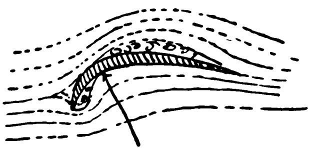


Fig. 3.

The other two explanations are mathematically expressed by Lord Rayleigh in a paper given before the Manchester Literary and Philosophical Society in 1900. They may be briefly summarised as follows :—

(Second).—The velocity of the air currents is known to be greater as the height from the earth increases, so that a bird sinking towards the earth is subject to a velocity difference which applied to its inertia does work, and may be employed in travelling against the wind.

It has to be remembered that the body of a bird has exceedingly small air resistance. This explanation involves, however, circling in the air, with and against the wind, so that it is not applicable to the soaring flight referred to by the querist.

(Third).—The velocity of the wind varies enormously in a small space of time (see Professor Langley "On the Internal Work of the Wind") and passes through an approximately periodic change. The velocity differences so occurring will cause the relative velocity of the bird to the air to be variable, this variation being under certain conditions a source of kinetic energy. This certainly seems the most rational explanation, although probably the actual phenomenon depends on a combination of these factors.

With regard to the lateral swaying of the birds, this is a necessary feature in all flying machines since the reactions on each side will constantly be varying. I have dealt with this matter in "The Problem of Flight," pages 108 *sqq*.

FROM THE STARTING PLATFORM.

THE MARINE STEAM TURBINE.

The impression is somewhat widespread that for marine purposes the Curtis, or perhaps one should call it, the Ferranti type, of velocity compounded turbine, has some material advantages over that introduced by Mr. Parsons, though the latter is admittedly superior to its rival when the conditions are such that both are working somewhere near their most economical speeds. In marine work, however, the Parsons' turbine, at any rate, is always much underspeeded owing to the limitations imposed by the screw. In the early days of ship propulsion, the screw propeller was regarded as a giddy young thing requiring to have its impetuosity reduced by gearing to the sedate pace of the engine, but now, in its maturity, it is mated with a partner which votes it decidedly slow. By adopting partial admission and velocity compounding, it would seem at first sight the easiest possible matter to construct a marine turbine to run at almost any speed, no matter how slow. A more careful analysis of the problem, nevertheless, soon shows that the scheme, plausible as it seems, is by no means free from very distinct objections. In the first place, with each additional velocity stage, the blade losses of the turbine are greatly increased. Thus in some experiments made by the Allgemeine Company, a blade efficiency of 80 per

cent. was obtained with a single wheel, whilst with two velocity stages, the best efficiency was 66 per cent., and with three, 60 per cent. Somewhat better figures are, no doubt, now obtainable by improvements in the forms of the bucket, but the general run of them is unaltered. In practice, therefore, it is usual to divide up the Curtis marine turbine into seven pressure stages. In the first of these pressure stages one quarter of the whole work is done, and in it there are four velocity stages. Each of the remaining pressure stages does one-eighth of the total work, and has in it three velocity stages. With this arrangement, however, it is not easy to run the turbine at its proper blade speed. Considerations of cost and of the increased losses by fluid friction, make it necessary to keep down the wheel diameter, and similarly the questions of cost and weight make it impracticable to substantially increase the number of pressure stages. Hence in practice, the velocity compounded marine turbine seems to be considerably underspeeded, though less so than the Parsons' type, but the latter has a higher inherent efficiency to begin with. In the "Creole," for example, the Curtis turbine wheels are 10 feet in diameter, and the blade speed is about 250 feet per second, whilst from the Allgemeine curves a speed of about 400 feet per second would be needed to secure a maximum of efficiency.

Of course the "Creole" is a relatively slow boat, and allowances must be made for this fact in comparing it with Parsons' boats, of which sufficiently full particulars are available for determining the thermodynamic efficiency of the plant. With the "Creole" the best result attained was an efficiency ratio of 44 per cent. On the "Mauretania," on her 26 knot runs, the steam consumption recorded corresponds to an efficiency ratio of 67 per cent. With the "Lusitania," a somewhat lower figure was observed, but this may have been due, in part at least, to the torsion meter errors favouring its rival. On the "Dreadnought," at the so-called full power trials, the overall efficiency was 61·3 per cent., but this must have been very substantially exceeded on the runs in which over 28,000 H.P. were developed. In the "Dreadnought," as generally, the efficiency of the low pressure turbine was substantially greater than the high pressure one, the figures being respectively about 56 per cent. and 63 per cent. The leakage loss through the high pressure dummy in itself amounted to about

8 per cent. of the total steam entering the turbine. With the Curtis type there appears to be less difference between the efficiency of the high pressure and low pressure ends of the turbine. Thus from figures published by Mr. Emmott, we deduce the following values for the efficiency of the first pressure stages of the "Creole" turbines:—

Stage No.	1	2	3
Efficiency ratio	41·3 per cent.	47·1 per cent.	39·1 per cent.

The efficiency ratio for the first three stages taken together is 44·2 per cent., or practically the same as that of the turbine as a whole. The figures above given are deduced from measurements of the temperature and superheat. Of course the efficiency does not tell the whole of the story. In the Curtis turbine initial steam pressures are commonly higher than they are with the Parsons' type, so that the difference in the coal consumption is less marked than the differences in efficiency ratio. In fact, it is common knowledge that the steam consumption of the "Rewa," a boat corresponding very closely to the "Creole" in dimensions and speed, is not very markedly better, though the efficiency ratios are higher.

H. M. MARTIN.

OBSERVATIONS IN GENERAL.

The Juniors had quite a field day on Saturday, the 23rd May, at Avonmouth Docks, when, favoured with ideal weather, they inspected the fine work being carried out by Messrs. John Aird and Son.

* * * * * *

There was a most creditable muster of the Institution. Together with the local and district members who joined the party, there were over one hundred present, somewhat to the agreeable astonishment of our Secretary and hosts. It was remarked at the luncheon, so kindly provided by the Contractors and so genially presided over by Mr. F. Colson, that we were the largest party so far who had visited the works. Appropriate messages were telegraphed to Sir John Aird, Bart. (Vice-President) and to his son Mr. Malcolm Aird (Hon. Member).

It was gratifying and pleasant to meet our provincial members on this occasion, and to find that so responsible a position as Resident Engineer was being filled by a member of the Institution in the person of Mr. Don Swan, who remarked when extending the hospitality of a welcome afternoon tea to us that "the more he saw of the Juniors the more he liked them."

* * * * * *

The construction of these Docks and the whole equipment with which they are being completed, presented an object lesson in the quality of British workmanship, for no foreign appliances or material were noticed by the writer, with the exception of some Norwegian granite. The adoption of ferro-concrete for the large grain storage warehouse showed that the Bristol authorities are progressive in constructional methods. The combination of electric and hydraulic power was evidently favoured throughout the Docks. The development of this Dock Estate, together with the electric light and power extensions in hand at the Avonbank Electricity Works, which our electrical members especially found so deeply interesting, shows that the Bristol Corporation are going ahead and mean to keep the Port of Bristol in the front rank.

* * * * * *

We observe that Mr. Dugald Clerk, F.R.S. (Past-President), is to be President of Section G (Engineering) at the forthcoming meeting of the British Association which is announced to be held at Dublin in September; and further, that he has been nominated for election as an Honorary Member of the Institution of Gas Engineers.

* * * * * *

Mention of the British Association brings to mind the name of one of our recently-elected Vice-Presidents, Professor J. J. Thomson, F.R.S., who is to be President of the Association's Meeting next year.

* * * * * *

Members present at our memorable Aerial Navigation meeting in February will have noticed with much interest that Count de la Vaulx (Hon. Member) took part in the recent aerial race from Hurlingham, his balloon being "L'Escapade." The Hon C. S. Rolls also competed in "The Corona."

Before the next number of our Journal is published the Institution's Summer Visit to France will have opened. We are glad that the number registered for the Paris rendezvous on 27th June is steadily increasing.

*   *   *   *   *   *

Having regard to the way in which our Institution has of late identified itself with questions relating to the navigation of the air, how appropriate would have been the journey from London to Paris by airship of European—not American—build, manned by some of the more intrepid of our members, with Capt. Ferber at the helm, but we hear nothing of such an arrangement.

*   *   *   *   *   *

Just think of the exhilarating and exciting possibilities of such an experience, with no *mal de mer* to reckon with—merely *mal d'air*, which must be quite a different sensation.

*   *   *   *   *   *

"10 a.m., leave the Port of London aerial docks by airship 'Londres Paris'; 12.30 p.m., arrive Paris, disembarking at the landing stage of the Eiffel Tower," sounds distinctly progressive. We wonder how it would feel. But this is not yet; we shall proceed *via* Newhaven-Dieppe by the prosaic principles of aqueous navigation. *Bon voyage!*

*   *   *   *   *   *

In the appendix to the address of M. E. Cornuault, as retiring President of the Institution of Civil Engineers of France, a list is given of the names of members on whom various distinctions have been conferred, we notice the name of our President, M. Gustave Canet at the head of the list as Commander of the Legion of Honour; and amongst those who have received foreign decorations, his name occurs as the recipient of the naval Grand Cross of Merit of Spain, and the decoration of the First Class of the Third Grade of the Double Dragon of China.

*   *   *   *   *   *

We offer M. Canet our cordial congratulations.

AUTOMATIC FIRE EXTINCTION.

The Thirteenth Visit of the Twenty-seventh Session took place on Monday evening, 16th March, 1908, at 6.30 p.m., to Messrs. Mather and Platt's Automatic Fire Sprinkler Testing Station, Horseferry Road, Westminster, the attendance being 33.

The members were received by Mr. J. W. Spiller, under whose direction a demonstration was carried out to illustrate the actual operation of the experimental plant. The following particulars of the Station and of the various features of the demonstration have also been kindly furnished by him. Before dispersing, the acknowledgments of the party for all that had been done to render the visit so interesting were conveyed by Mr. G. T. Bullock (Vice-Chairman) and Mr. Spiller briefly responded.

The testing house consists of a yard in which is a small shed measuring internally 20 feet by 10 feet by 10 feet high. This shed has three windows on each side, for observation purposes, and is of brickwork up to the window sills, but above those it is constructed of light matchboarding, as also is the roof. Altogether, the upper portion of the shed is of very bad construction—from a fire-resisting point of view—and was specially arranged to show that however badly constructed a building may be, equipping it with "Grinnell" Automatic Sprinklers renders it absolutely fire-resisting. The shed has been in use for over twelve years, during which time fire tests have been held in it weekly, so that it has been subjected to fire many times.

The equipment in the shed consists of two sprinkler heads set to fuse at 155°F., the sprinklers being taken from stock as commercially used. The supply to these sprinklers is a 2 inch branch from the mains of the Chelsea Section of the Metropolitan Water Board. A 2 inch stop valve, alarm valve, waste valve, testing valve, a standard mechanical alarm gong, and also an electrical alarm gong are fitted, so that the installation is to all intents and purposes a complete one, but with only one water supply.

In addition to the equipment inside the shed two sprinkler heads are fitted to pipes in the centre of the yard, which is 20 feet square. One of these sprinklers is fitted in an inverted, and one in a pendant position. Both sprinklers are open, *i.e.* as they would be after operating on a fire. Each of these heads is fed

by a $\frac{3}{4}$ inch pipe from the water supply, the object being to demonstrate the distribution of water from the heads.

Firstly, water was turned on to the pendant sprinkler head and was diffused in the form of fine rain which covered the whole of the yard, *i.e.* 400 super. feet. In addition, the water from the deflector rose about 2 feet, showing that it would have thoroughly drenched the ceiling had there been one above it.

Water was then turned on to the inverted head with, if anything, a slightly wider spread of water, indicating clearly that the one sprinkler head would protect an area of 400 super. feet if the water pressure is a least equal to that at the testing shed, viz., 45 to 50 lbs. per square inch, whereas by the rules of the Fire Offices' Committee the maximum area which one sprinkler head can protect is 100 super. feet.

The action of the alarm gong was then demonstrated. Above the alarm valve there is a $\frac{1}{2}$ inch testing valve arranged (this testing valve being the same size as the opening of one sprinkler head). On opening this valve water passing through the alarm valve at once operated the mechanical alarm gong and also the electrical alarm bell, and it was demonstrated that as long as water flowed through the alarm valve, so long would the gongs continue to ring, unless they were shut off. It was pointed out that the pipe which led to the small Pelton wheel, which revolves the hammer of the alarm gong, was so arranged that provision is made for this pipe always to be empty, so that frost could never interfere with the action of the bell, this being achieved by means of small outlet or "drip" union, which allows the water in the pipe to gradually drain away.

The small sample installation of two sprinklers was then fully charged with water, and the stop valve and alarm cock fully opened, exactly in the manner in which installations are maintained ready for action. About three sacksful of dry shavings were heaped up on the wooden floor of the shed to a depth of about 2 feet, covering the greater portion of the floor. These shavings were well lit in two or three different places, the attendants who lighted up clearing out of the shed and closing the doors behind them. In the gathering gloom the flames from the shavings rose, and after a pause (what doubtless seemed a very long time to those who had never seen such a demonstration —but actually 59 to 60 seconds) with two sharp reports the

sprinklers opened and immediately the flames began to subside. At the same time the mechanical alarm gong rang out and the electrical alarm sounded. After allowing these gongs to ring for a short period they were shut off. Water was allowed to play on the fire for a period of 2½ minutes, then the windows, doors and roof were thrown open to drive the smoke out of the shed. Water having been turned off, the shed was entered, and it was seen that in spite of the fierce flames, as witnessed, only the top layer of the shavings had actually been burnt before the sprinklers operated and put out the fire.

Water was then turned on to the open sprinklers and lamp-light being thrown into the shed it was demonstrated that the whole of the ceiling, walls, and floor of the shed were thoroughly drenched with the fine spray, leaving no dry spot.

The sprinkler heads which had fused were unscrewed and handed round for inspection.

BIRMINGHAM LOCAL SECTION.

The Seventh Meeting of the first session of the Birmingham Local Section was held at the headquarters of the Electrical Engineers Volunteers (Birmingham Detachment), on Thursday, 9th April, 1908, the attendance being 14. Mr. F. S. Pilling (local Chairman) took the chair at 8 p.m., and the minutes of the previous meeting were read, confirmed and signed. The Hon. Secretary (Mr. R. B. A. Ellis) then read Mr. G. H. Hughes' paper on "The Purification of Water," which had been given before the London meeting on the previous Tuesday.

At its conclusion a hearty vote of thanks was accorded by acclamation to the author, on the motion of Mr. E. G. S. Vaughan, seconded by Mr. E. E. Jeavons. Mr. E. J. Jewell, speaking at some length, referred to the chalky deposit resulting from the process of purification of waters of a certain composition, and understood that it was of little value. He mentioned the fact that the Burton water contained about 50 degrees temporary hardness, and also alluded to the Paterson filter.

Mr. T. H. Relton, Mr. R. Berry, and Mr. R. B. A. Ellis also took part in the discussion; and the Chairman, in his concluding remarks, thought it would have added interest to the paper if the author had dealt more with what the man in the street

wanted to know about the water supplied to him. He mentioned the growth of oscillaria in the Staines reservoirs, and drew attention to the position of the inflow which, as it was near the syphon, precluded the beneficial effects of circulation being taken advantage of.

Before the meeting closed he felt that he ought to make reference to the announcement in the April number of *The Journal* that the Institution membership must now be expressed by four figures, and, at his suggestion, it was agreed that the congratulations of the Birmingham Local Section should be sent to the parent body on this splendid achievement. With the notice of the ensuing meeting in May, when Mr. Durham's paper on "The Design of a Sewer" would be read and discussed, the proceedings terminated.

"THE PURIFICATION OF WATER."

By GEORGE H. HUGHES, M.I.Mech.E.
(Member of Council for the Eastern Counties).

Read 7th April, 1908.

Water for public supply should be clear and bright, without colour, taste or smell, agreeable for drinking, free of pathogenic bacteria, or injurious chemicals, either in suspension or solution.

Absolutely pure water (H_2O) cannot be obtained from nature. Pure water, in the hygienic sense, means water free from harmful ingredients, suitable for drinking and domestic purposes.

The water supply of the earth is derived from the atmosphere and the clouds, which receive water evaporated from the surfaces of the land, rivers and sea. In its cycle from sea to cloud, atmosphere to earth, over the surface of the earth, into streams and rivers, and in its percolation through the earth into wells, water takes up both inorganic and organic substances, some of which are harmful and objectionable to man.

In its percolation through the earth, water is also purified by filtration; the organic matter is removed by the nitrifying organisms in the soil and by oxidation.

From very ancient days, man has striven to remove foreign substances from water. The Japanese and Egyptians are credited with having used at a very early period, vessels of sandstone or unglazed earthenware, for the purpose of filtering water. The stone was hollowed out into the form of a mortar, with small projections near the top for resting on a wooden frame which supported it; a vessel was placed below to receive the filtered water. The unfiltered water on being poured into the hollow stone, passed through with tolerable facility, the solid impurities retained in the stone being cleared out as required. Many centuries have passed, and this early filter has been much developed by man.

The system of allowing water, by its gravity, to percolate through a porous body has been found to be very efficient in removing matter in suspension. Fine sand has taken the place of porous sandstone, and is now considered to be the best filtering medium.

Waters from upland surfaces may contain much, little, or no organic matter; they may be rich or poor in minerals, their qualities may vary according to the seasons, rainfall, geological conditions, rate of movement, vegetation, and other conditions. Such waters require their impurities removed or reduced, to render them suitable for a public supply.

Sedimentation.—To remove the grosser solids in suspension it is advisable to allow the water to rest in tanks or reservoirs before passing it on to the filters. This process is termed sedimentation.

The intake from the stream or river should be provided with a screen of about a quarter inch mesh. A suitable screen may be made of flat iron bars about 1¼ inch wide by ¼ inch thick, spaced about ¼ inch apart, placed at an angle, and provided with a trough at the top, into which garbage, leaves, and other substances may be raked. After passing the screen the water is conducted by suitable pipes or conduits to the sedimentation tank or tanks.

Sluice valves or gates, controlling the supply, may be provided, preferably upstream of the screens.

It is advisable that a plurality of sedimentation tanks should be provided and fitted with sludge washout valves, for the removal of deposited materials, so that one tank may be cleaned out whilst the other is in operation; and floating outlets are advisable, so that the upper clear water may be conducted to the filters.

During the process of sedimentation, in addition to the deposit of a large quantity of matter in suspension, the water is much improved in other respects, as is shown from the report of Dr. T. E. Thorpe, which appeared in the "Times Engineering Supplement" of 1st May, 1907:—

The wisdom of providing against a dry day by making the rainy day do it was generally allowed by every one who had the management of London's water supply.

Not only is it prudent to store the water, but that storage itself greatly improves its character.

It is now clearly established that organisms known to be pathogenic have no chance in the struggle for existence with bacteria, which are normal to natural water, and given time and exposure to light and air they disappear.

There is, however, another effect of storage on the character of the Metropolitan Water Supply which is hardly less important to the users, and that is, the diminution of its hardness; the Thames water varying from 20 to 23 parts per 100,000 leads to an undue consumption of soap and causes "furring" in boilers, hot water pipes, &c.

By storing, a considerable proportion of the chalk is precipitated owing to the dissipation of dissolved carbonic acid, or its removal by cholorophyll-containing organisms.

The following figures give a comparison:—

		Parts per 100,000.	
		Raw Thames Water.	Stored Staines Water.
1903.			
Total dissolved matter	...	30.23	23.28
Total hardness	...	21.20	16.00
1905. (30th November.)			
Total dissolved matter	...	32.80	23.06
Total hardness	...	20.90	15.10

The figures given below show the difference between a typical Thames water after short storage and filtration and filtered Staines stored water—a reduction due to storage of 50 per cent. in hardness and of over 50 per cent. in the coloured units.

1906. (10th December.)		Parts per 100,000.	
		Thames Water.	Staines Water.
Coloured units ...	...	26.5	11.5
Carbonates as chalk	...	18.8	9.0

The author remarked at the time of reading the above report—What will happen if Algæ develop in this body of water? Subsequent events proved this question prophetic, and will be referred to later under "Sterilisation."

The following extract from "The Daily Telegraph," of 7th April, 1908, refers to the improvement in London water by storage as regards pathogenic bacteria:—

"In the course of the year 1906-7 storage capacity to the extent of a million and a half gallons was added to the Board's reservoirs, and even greater extensions are in progress. On this point the following opinion of Dr. Houston, the director of water examinations, is of considerable interest: "The chief importance of storage lies in the fact that micro-organisms of water-borne disease gradually die when they have to contend against the ordinary water bacteria in the struggle for existence. All the available evidence points not only to the practical inability of the pathogenic bacteria to multiply in water, but also to

the fact that their loss of vitality is only a question of time. If water is stored for weeks or months the probability of harmful bacteria surviving becomes excessively remote. Water stored sufficiently long, even if turbid or unpalatable, is, in the light of present knowledge, incapable of giving rise to epidemic disease."

FILTERS.

From the sedimentation tanks the water is next conducted to the filters, which may be of (1) the gravitation type, (2) the mechanical type without chemicals, (3) the mechanical type with chemicals.

Gravitation Filters.—Where the levels permit of it the water flows by gravitation, from the sedimentation tanks on to the filters. In some cases it is necessary to pump the water from the river to the sedimentation tanks, or from the tanks to a reservoir above the filters, or direct to the filters, but the last named system is not to be recommended, as the variation of pumping causes irregularity in the supply to the filters. A gravitation supply to the filters is best.

The height of water above the top surface of the filtering media and the level of the water on a filter outlet require very careful adjustment, so as to ensure a rate of filtration suitable to the conditions of the filter and the quality of the water. Automatic-float-operated valves are advisable for this purpose. On the outlet side of the filter an adjustable weir will act as a very positive method of regulating the rate of outflow.

The size of the sand, the depth of the sand, and the method of conducting the filtered water away, all require very careful attention, so as to ensure an uniform downward flow of water throughout the whole area of the filtering media. No pipes or irregularities should be allowed within a filter, as they are liable to cause a readier passage of the water down their smooth surfaces than through the filtering media, and so cause a short circuit. For this reason all air pipes and valve spindles should be exterior to the filter bed as far as practicable.

A gravitation filter is usually constructed of a number of bays or compartments, each about one acre in area, so that the cleaning of one unit does not interfere with the others. Each bay consists of a large tank, the walls constructed of masonry, brickwork, or concrete, the floor of concrete, the whole made

water-tight both from internal and external leakage. The design should provide for easy access. Prevention of flood or entry of rain water is essential, and for this purpose the side walls and copings should be sufficiently high above ground level. The materials used for these wall copings and faces should be non-porous and capable of resisting frost and sun.

The author advocates the covering in of all filters by brick arches or by ferro-concrete arches, and an earth covering of at least 1 foot 6 inches thick, turfed over. This latter keeps the water at a fairly uniform temperature and excludes the dust and frost. The filtering media is usually some 6 feet thick, consisting of selected clean sharp fine sand on the top, about 3 feet thick; 1 foot of pea gravel; 1 foot of coarse gravel; and 1 foot of stones, 2 inch mesh. Drains may be arranged herring-bone fashion, and should be of 3 inch or 4 inch agricultural drains running into larger drains about 9 inches or 12 inches, and these again discharging into a drain about 18 inches to 24 inches, to give uniform downward flow of water through the mass and uniform support to the sand, the under drains being designed to carry the water away to the outlet well.

When first put into operation a filter bed of this kind effects but little improvement in the quality of the water; the finer particles of foreign matter are arrested in the sand, and after a time the sand grains become coated with a sticky slime composed of nitrifying organisms which indubitably cause the decomposition of organic matter in the water. Dr. David Sommerville, in a paper read at a meeting of the Society of Engineers on the 7th of May, 1906 (Transactions, p. 67) stated that the destruction of bacteria is not due directly to nitrification, but that the latter lessens the food stuffs in the water necessary to their life.

The particles of vegetable and animal matter, both living and dead, are partly retained mechanically, partly oxidised, and partly destroyed through the agency of these nitrifying organisms. The term "nitrifying" is given, because, in breaking up the organic matter, they cause its most characteristic element, nitrogen, to combine with the oxygen in the water, either dissolved or in the air present, forming "Nitrates," which are harmless.

After some time the surface becomes choked with an accumulation of foreign matter and slime, which has to be removed,

and it is sometimes so matted that it may be rolled up like a blanket. The sand to a depth of about half an inch, is also scraped off and washed for re-use. The duration between this removal of the slime layer and sand varies considerably, which will be readily understood when one considers the variation in the quality of raw water at the different seasons of the year. The average of the Metropolitan Water Board for the year 1907 was 40 days. The change in temperature from early spring to early summer frequently causes vegetation to develop in the filter beds very rapidly, necessitating the laying up of a filter to cleanse, sometimes so soon as two days. The depth of sand varies, and as examples of this, the author has compiled Table No. 1 in the Appendix, from the monthly reports of the "Metropolitan Water Supply," issued by the Water Examiner. Table No. 3 gives the filter area and area cleaned, and the author's deductions.

The size of sand grains, and purity of the sand are both essential considerations. The size is between 0·005 and 0·01 of an inch. Suitable sand may be obtained from Hayle in Cornwall, Leighton Buzzard, Southwold, Reigate and other places. It should be free from colouring matter and from any soft ingredients likely to be dissolved or crushed in operation. It should be as nearly as practicable of pure silica. Fairly finely crushed flints, or marble or quartz make an excellent sand.

The rate of filtration should not exceed from 450 to 500 gallons per yard super. per 24 hours. (Dr. Kotch gives 100 mm.—about 4 inches in depth—or a rate of 2·081 gallons per square foot per hour, or 450 gallons per yard super. per 24 hours), but the rate varies considerably with the seasons, and the conditions of the raw water and of the filter, especially the top layer. On examination of Table No. 2 in the Appendix, relating to the Metropolitan Water Supply, it will be found that the rate varies from 0·71 to 2·77 gallons per square foot per hour, and the mean for the year is 1·4206 gallons per square foot per hour, or 307·2496 gallons per 24 hours for each square yard superficial.

In deciding the size of the filter, allowance must be made according to the special circumstances, for increasing the filtering area, if otherwise, the filtration speed would exceed the rate of 450 gallons per yard (4 inches in depth of water passing through in 24 hours) which equals 2,222 square yards of filter superficial area for each million of gallons required

per 24 hours. An allowance of 20 per cent. for cleaning and 20 per cent. for fluctuations may be taken as a fair average for a preliminary estimate—0·88 acres per million. Table No. 3 in the Appendix shows that the Metropolitan Water Board have 0·827 acres per million gallons. Of course, where ample storage of raw water and filtered water permits, the allowance of 40 per cent. may be modified.

As an idea of cost, uncovered filters cost in England about £10,000 per acre, and covered filters £15,000 per acre. In London, according to Mr. W. H. Maxwell, A.M.I.C.E., Water Engineer, Tunbridge Wells, the cost of working is reported to be 3s. 0½d. to 4s. 9d. per million gallons, or an average of 3s. 10½d. per million gallons.

The average total depth of a sand filter may be taken as 9 feet, viz. :—

Margin above H.W.L.	... ...	1.00 feet.
Depth of water above sand	... ...	2.00 ,,
Depth of filtering media	... ...	6.00 ,,
		9 ,,

The cleaning of a filter is usually performed in the following manner :—The water is run off until it is about 6 inches below the surface of the sand ; if there be any weed it is rolled up and removed. The sand is skimmed off with shovels and removed either in barrows or thrown into a hopper, from which it is ejected by a hydraulic jet, and lifted to the sand washers. The Metropolitan Water Board use a series of these hydraulic ejectors, so that the lifting, removal and partial washing is effected *en route* to a rotary washer. It will be of interest to refer here to the ingenious sand washer devised by one of the members of the Institution, Mr. C. W. Pettit, who has had considerable experience in sand washing processes. The author hopes he will describe his apparatus in the discussion.

The washed sand is stored ready for re-use. When the thickness of the sand is reduced to the ascertained safe limit, the sand is replaced to bring the depth up to its proper level. The Water Examiners are able to decide the limit of depth of sand by the chemical and bacterial results obtained. For the year 1907 the raw Thames water contained, on an average, 2,365 bacterial

microbes per cubic centimetre, and the filtered water contained 174·4 bacteria per cubic centimetre. This, the author calculates, amounts to an efficiency in the filters of 92·5 per cent. *i.e.*, 7·5 per cent. of the bacteria passed through the filters as an average for the year 1907. A filter bed is not disturbed *en masse* for many years, unless some abnormal condition renders it necessary, such as vegetable growth and blocking of the drains, or blocking of the mass by algæ.

Other filtering media than sand are employed, and, in many instances, satisfactorily. The author has used silicated carbon, polarite, and coke, but he considers sand to be the best medium when all circumstances are taken into account. Substances of a porous or spongy nature are not easily cleaned.

As regards polarite, the following analysis is reported by Sir H. Roscoe, F.R.S. :—

Magnetic oxide of iron ...	53.85	per cent.
Alumina	5.68	,,
Magnesia	7.55	,,
Carbon and Water	5.41	,,
Silica	25.40	,,
Lime	2.01	,,
	100.00	,,

At Reading, where polarite is in use, the Water Engineer reports favourably on it, and states that the rate of filtration is 16,000 to 18,000 gallons per square yard of area per 24 hours, which is far greater than with sand filtration. Other claims in its favour are lesser area ; lesser cost ; and cost of cleaning 50 per cent. less than that of sand filters.

The bacteriological result for 750 gallons per hour only (the author has no figures for the higher rates mentioned) is given as follows :—

October, 1899	98.4	per cent.
November, 1900	99.48	,,
September, 1901	97.50	,,
December, 1901	95.40	,,
April, 1902	98.20	,,
January, 1904	98.90	,,
June, 1905	99.40	,,

At Reading the filter house (Southcote Works) is 109 feet 6 inches long by 32 feet wide, and has four sets of filters, each set in series. The water (from the river Kennet) enters one end, passes into a water chamber, and overflows into a sand filter 5 feet wide, down which it passes, through the bottom of the wall, into another water chamber, rises and overflows into a polarite filter 6 feet 4 inches wide; passes down through the bottom of the wall, and rises into another water chamber; overflows into a second polarite filter 7 feet 2 inches wide; passes down through the bottom of the wall into another water chamber; rises and overflows into a third polarite filter 10 feet wide, down which it passes and is thence conducted to the clean water reservoir.

The four sections are stated to be capable of filtering 800,000 gallons per hour, which works out at about 18,000 gallons per square yard super. of filtering media and water spaces.

The author understands that each section can be cleaned by one man in 10 hours, but has no information as to how frequently cleaning is carried out.

Mechanical Filters without Chemicals.—Mechanical filters—those in which the sand is washed without removal—consist of cylindrical vessels partly filled with filtering material, consisting mostly of sand. Some are open, and the water passes down by gravity, whilst others are closed and the water is forced through under pressure, so that a higher rate of filtration is secured. These filters are all practically combined filters and sand washers.

In the process of cleansing them the flow of water is reversed, by suitable pipes and valves. Mechanically operated rakes or stirrers are sometimes employed to agitate the mass. A mechanical filter is easily cleaned at frequent intervals. The driving back of the water from below under pressure loosens the whole mass of sand and causes it to bubble up and scour itself, the arrested foreign substances being washed away, whilst the sand, being heavier, remains.

For removing a large percentage of the impurities in *suspension*, sand filters are excellent. They are suitable for use in manufactories, and are also good for domestic application, where the water is free from bacteria. They are also convenient, and efficient in aerating water and removing iron, especially when

suitable media is used. They may also be applied advantageously, as roughing filters, to remove all matter in suspension before passing the water on to the filter for the removal of bacteria and other microbes. They may also be advantageously employed to filter the effluent from water softening plants where the large precipitation tanks could not be employed on account of the space and cost.

Each 3 feet area will filter 9,000 gallons per 24 hours, or 27,000 gallons per square yard area, as compared with 450 to 500 gallons per 24 hours for gravity sand filters.

Mechanical Filters with Chemicals.—Alum has been used for centuries to precipitate matter in water. With the greater knowledge of the bacteria in water, it was discovered that by the use of a small quantity of alum (about ·5 of a gram of sulphate of alumina to the gallon), a slime layer could be artificially formed very quickly, and so could effect a result equal to the best sand filters.

The sulphate of alumina becomes decomposed or changes into sulphuric acid and alumina. The acid combines with the lime in most waters (or this can be added also) while the hydrate of alumina is precipitated in a gelatinous mass and adheres to the surfaces of the sand grains, arresting the bacteria, also the colouring matter in some waters.

Results show that filters of this kind give in some cases a bacteriological efficiency of 99·87 per cent.

It may be asked why not use sulphate of alumina on the ordinary gravitation beds, so as to get them into condition quickly? The answer is that it is impracticable, as the sulphates and alumina hydrates cannot by the present methods of sand washing, be washed out readily, but in the mechanical filter this is easily done.

The author is of opinion that in the future mechanical filters will surpass the old type of open filter beds, not only as regards initial cost and economy of cleansing, but on account of their greater bacterial efficiency when scientifically controlled and properly looked after. This can only be done by chemical and bacterial examination of the water at frequent intervals, and the same remark applies to sand filters.

Amongst various types of mechanical filters may be mentioned the Atkins; the Bell; the Boby; the Candy; the Jewell; the

Mather and Platt; the Paterson; and the Stanhope; but the limits of the present paper will not permit of a detailed description of each. It may be mentioned that all of them are in use for public water supply and give entire satisfaction.

The Bell filters are referred to by the author in his paper before the Institution on 7th April, 1905 (Transactions, page 211). He inspected them at Gloucester in 1906, and was satisfied as to their efficient working. As regards the Boby "Ferrochlore" process, he inspected a Boby filter before it was despatched to China, and believes this class of filter, with its combined treatment, is an excellent plant, especially to treat water containing pathogenic bacteria. Dr. Adolf Kemna, Chief Engineer to the Antwerp Water Works, referred as follows to the "Ferrochlore" process in a paper which he read to the American Society of Civil Engineers at the St. Louis Exhibition in 1904, in reference to the plant at Middlekerke:—"The results are satisfactory. Recent experiments at Paris on the spring water of the Varne show that with 0·5 parts per million gallons of chlorinated lime and 8 parts of chloride of iron at the outlet of the filter, 250 germs per CC. are reduced to 13 germs per CC., and that B. Coli are absent. With larger quantities of the re-agents complete sterilisation can be obtained."

With reference to the Paterson filter, the author is pleased to call special attention to the invention of another member of the Institution, and hopes Mr. Paterson will add to the value of the discussion by taking part in it, and giving particulars of this type of filter, in which the water admitted into an annular space above the sand overflows the edge, in the form of a circular weir, and is thereby distributed uniformly. The same weir, when the filter is reversed for washing, acts as a trough to conduct the dirty water away.

WATER SOFTENING.

The most usual methods of water softening are:—(1) The Lime Process; (2) Soda Process; (3) Combination of the two.

Lime Process.—Dr. Clark, of Aberdeen, some fifty years ago invented the lime process to soften waters containing bicarbonates of lime and magnesia. The added lime combines with the carbonic acid of the bicarbonates, forming simple *i.e.* monocarbonates of lime and magnesia, which are then insoluble and are precipitated.

The chemical re-action for the bicarbonates of lime is :—

$$CaO,\ 2CO_2 + H_2O = 2(CaO,\ CO_2 + H_2O)$$

and for the magnesia bicarbonates :—

$$Mg\,O,\ 2\,(CO_2) + Ca\,H_2O_2 = Mg\,O,\ CO_2 + Ca\,O, CO_2 + H_2O.$$

The Soda Process.—Carbonate of soda, hydrate of soda (caustic soda) added to the water containing sulphates of lime and magnesia re-acts on the sulphates and forms carbonates, which are precipitated, whilst the neutral sulphate of soda remains in solution.

The re-actions are :—

$$Ca\,SO_4 + Na\,CO_3 = Ca\,CO_3 + Na_2\,SO_4$$

and :—

$$Mg\,SO_4 + Na_2\,CO_3 = Mg\,CO_3 + Na\,SO_4.$$

If bicarbonates are present the action is interfered with and bicarbonates may be formed, but by heating such water the extra atom of carbonic acid can be driven off and the mono-carbonate is precipitated. If caustic soda be used the action is :—

$$Ca\,SO_4 + CO_2 + 2NaHO = Ca\,CO_3 + H_2O + Na\,SO_4.$$

Any bicarbonates of lime and magnesia thus deprived of its carbonic acid will also be precipitated, and the double action is :—

$$Ca\,O,\ 2(CO_2) + CaSO_4 + 2Na\,HO = 2\,CaCO_3 + Na_2\,SO_4 + H_2O.$$

If there is any excess of CO_2 the lime then remains in solution.

Combination of Lime and Soda Processes.—By the combined addition of the correct quantities of lime and soda nearly all the carbonates and sulphates of lime and magnesia may be precipitated.

A softening plant consists of a tank or vessel to hold the lime or soda ; preferably, they should be in solution, so that a measured quantity of known strength is added to a measured quantity of the water to be treated.

On a large scale where the space is available, the following is the best method :—The solutions should be made to mix with the raw water whilst both flow into a settling tank. After resting in the tank the reaction is completed ; the insoluble carbonates and sulphates are precipitated and ultimately rest on the bottom, and the clear water may be drawn off, the time occupied of course varying according to the depth of the tank, a period of twenty-

four hours being taken in some cases. By means of a floating outlet about 12 inches below the surface, the clear water may be easily drawn off. Two or more precipitation tanks should be employed, so as to give constant supply and allow for cleaning out as required. It may be added that the precipitated chalk has a fair sale for tooth powders, &c.

In the smaller plants and in continuous processes the solutions are made to mix with the inflowing water, either measured by tanks and tilted in, syphoned in, or made to pass through an orifice of ascertained capacity, to ensure correct proportion to the inflowing water.

The combined fluids are conducted to mixing and precipitation chambers, and thence through a rough filter of wood wool, or canvas, to arrest any floating particles of chalk, and, in some, finally through a mechanical sand filter. In the Bell apparatus, the Paterson, and some others, this additional filter is provided, and, as already mentioned, can be readily cleaned.

STERILISATION.

Sterilisation may be effected by means of (1) copper sulphate; (2) hypochlorites; (3) ozone; (4) boiling.

Copper Sulphate.—The author was engaged in 1906 to deal with a South African water, which was occasionally subject to the rapid development of algæ. At a dry season of the year the river water had very little flow, when the algæ developed very rapidly, causing a fishy taste to the water and discolouration. The filter beds became choked, and the algæ adhered to the pipe surfaces. As a temporary measure he advised the application of copper sulphate of from one part to eight parts per million.

Experiments were made, and three parts per million were found to be an efficient algæcide. The copper sulphate was put into canvas bags and towed over the surface of the settling tanks and reservoir; the filters were thoroughly cleaned, and afterwards everything washed out. On careful chemical and bacteriological tests being made no trace of copper whatever was found in the water supplied to the consumers. The remedy appears to have been quite satisfactory, for no complaints were received for the the year 1907. The repeated use of copper sulphate, is not to

be recommended, but immediate application is justifiable in cases of such emergency, if every precaution is taken to prevent any copper being conveyed to the consumer.

In America, the use of copper sulphate has received a great deal of attention as a germicide and algæcide, and with reference to its application in England, reference may be made to the experience of the Metropolitan Water Board, who had to deal with an outbreak of algæ at the Staines reservoir. The August (1907) report of the Metropolitan Water Examiner contains details of the reservoirs and filters affected by this outbreak. The dose of copper sulphate adopted was from 1 to 1 million to 1 in 5 millions, and was applied in sacks hung from boats rowed about the surface until the copper sulphate was all dissolved, with the result that in one case the analysis of 7,000 oscillaria per CC. was in less than three weeks reduced to 10 per CC. In concluding his report the Examiner states it cannot be disputed that the circulation in the Staines reservoir leaves much to be desired, and it is possible that an improvement in this direction might be beneficial.

The author suggests that in questions relating to the circulation of a large body of water like that at Staines, which presents such difficulties, the utilisation of windmill pumps might advantageously be considered.

Hypochlorites.—As a safer germicide an electrolytic hypochlorite solution may be adopted.

Common salt is split up by electric current into its constituents, and combines with the oxygen and hydrogen in the water, forming an unstable hypochlorite which is fatal to all forms of bacteria and algæ. In less than twenty-four hours the hypochlorite re-combines with the sodium, forming common salt, which is harmless to man in the small percentage left in the water. (It could not be detected by taste).

The most recent practical invention is the Pollard-Digby electrolytic cell, which enables the hypochlorite to be produced at a very reasonable cost. This is described in a paper by Messrs. Digby and Shenton, read before the Society of Engineers, 3rd December, 1906 (Transactions, page 229), in which they state that with water requiring 1 part in 420,000,

ninety thousand gallons could be treated for 10d. at London prices for salt and electricity.

The author has calculated that on such a basis the treatment of London water with 0·6 parts per million to effect sterilisation would cost 2s. 4d. per million gallons for salt and electricity.

At Guildford, Dr. Rideal has under his observation the treatment of the sewage effluent by oxychloride, a process which the author understands is similar to the "Digby," but that the cell of the latter is so ingeniously arranged that the efficiency of the plant is greater, a very high percentage of available chlorine being produced, with a minimum of electricity and salt employed in its production. Dr. Rideal's conclusion at Guildford was that with about 5 parts of available chlorine per 100,000 in the sewage effluent, sterility was ensured, and that 0·05 was enough to remove B. Coli and enteretidis.

It is generally accepted that if B. Coli are not found in 100 CC. the water is safe to use, and is presumably free from pathogenic bacteria. From the reports of the Water Examiner it may be seen that B. Coli were present in the filtered water in 100 CC. on a great many occasions. That there is danger from this fact cannot be denied, and it points to the advisability of subjecting the filtered water to some process of sterilisation.

Valuable information would be afforded by following the percentage of bacteria present during the autumn, both in the raw and filtered waters, and comparing the number of persons suffering from typhoid in the Metropolitan Water Board's area during the same period, allowing the fourteen days incubation period. The cases notified under the Diseases Notification Act would be fairly representative.

Ozone.—Ozone plants have been applied at West Philadelphia, U.S.A., Ginnetser, Holland, and elsewhere, but the author knows of none in England.

An electric arc is formed and current at about 10,000 volts passes across a number of points like two long combs on the positive and negative poles. Air is drawn or forced through this electric grating and is converted into ozone, which is forced through a stream of water. Usually the water descends a pipe or pipes, and the ozone is forced up against the stream whereby bacteria is destroyed.

The ozonisation should be performed after the bulk of the organic matter has been removed in settling tanks and filters, and should be considered as a finishing process only, or a final germicide.

Oxygen having such an affinity for organic matter, it would be wasteful to use ozone to remove what can be more cheaply removed by other and easier means.

AERATION.

Water containing iron is much improved by aeration, it being possible to remove 85 per cent. of the iron in this way.

Conducting the water over artificial cascades, weirs, terraces, or steps, or pumping it through jets so that the water-drops fall through the air, are effective methods.

It has been claimed by some that jets of air under pressure give improved results, but this has not been proved in practice.

Aeration through porous bodies containing air spaces, has been successfully carried out for precipitating the excess of iron, such as occurs in many spring and well waters. The Candy filter at Hastings may be cited as an instance of this.

The boiling of water is a well-known method of rendering it safe for domestic purposes, but water so treated is flat and unpalatable, and requires aeration.

Conclusion.—The author hopes that his brief observations will elicit from the members plenty of criticism in the course of the discussion, and in conclusion, feels he cannot do better than quote the following words of Dr. Sommerville :—" The well-informed water expert must be an intelligent student of many subjects. Geology, chemistry, biology, bacteriology, engineering and medicine, all claim his earnest attention. In the matter of water examinations he will not pin his faith to any one method to the total or partial exclusion of others, but will welcome all reliable methods that can assist in throwing light on his search."

APPENDIX.

TABLE No. 1.

THICKNESS OF SAND—FOR THE WHOLE YEAR—JANUARY TO DECEMBER, 1907.

Compiled from the monthly reports of the Examiner of the Metropolitan Water Supply.

Reference No.	District.	Maximum.		Minimum.		Mean.	
		ft.	ins.	ft.	ins.	ft.	ins.
1	Eastern ...	2	6	1	6	2	0
2	New River ...	2	3	1	7	1	11
3	Lambeth ...	3	0	2	6	2	9
4	Southwark and Vauxhall ...	3	0	2	3	2	7½
5	Chelsea ..	4	3	3	3	3	9
6	Grand Junction	3	0	2	3	2	7½
7	West Middlesex	2	9	2	6	2	7½
8	Kent ...	No Filtration.					

TABLE No. 2.

AVERAGE RATE OF FILTRATION—METROPOLITAN WATER SUPPLY FOR THE WHOLE YEAR—JANUARY TO DECEMBER, 1907.

Per square foot per hour, in gallons.

District. Ref. No.	January.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.	Mean.
1	1·31	1·30	1·10	1·10	1·20	1·11	0·85	0·71	0·80	0·80	0·73	0·94	0·996
2	2·59 1·10	2·34 1·07	2·500 0·958	2·49 1·21	2·53 1·32	2·56 1·45	2·63 1·22	2·59 1·25	2·60 1·35	2·77 1·26	2·69 1·50	2·45 1·26	2·56 1·265
3	1·79	1·82	1·71	1·80	1·63	1·83	1·16	1·90	1·90	1·80	1·76	1·77	1·74
4	1·00	0·92	0·93	1·02	1·17	1·24	1·96	1·08	1·03	1·00	0·96	0·96	1·15
5	1·142	1·52	1·53	1·575	1·588	1·587	1·641	1·709	1·566	1·642	1·558	1·498	1·555
6	1·142	0·905	0·854	0·827	0·891	0·873	0·919	0·854	0·837	0·870	0·839	0·799	0·884
7	1·142	1·270	1·216	1·212	1·201	1·193	1·441	1·238	1·236	1·149	1·144	1·132	1·215

The Total Mean being 1·4206 gallons per super. foot per hour, which amounts to 307·2496 gallons per super. yard per 24 hours.

TABLE No. 8.

DETAILS OF FILTER CLEANING OF METROPOLITAN WATER SUPPLY.

161 Filters. Area $161\frac{11}{12}$ Acres = 1 Acre per Filter.

District. Ref. No.	Filtering Area. Per million gallons.	AREA CLEANED—IN ACRES											
		January.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	October.	Nov.	Dec.
1	0·746	17·00	7 00	11·000	8·000	10·000	11·500	10 000	11·500	11·000	10·000	10 000	8 500
2	0·503	20·21 9·00	15·31 9 00	18·487 14·250	19·040 24·000	58·936 24·750	20·609 13·500	22·362 15·750	21·939 10·500	18·450 7·500	23·345 7·500	22·762 10·500	22·712 10·500
3	0·454	9·00	9·00	7·500	11·000	10·600	11·000	24·000	12·000	12·500	10·600	11·500	13·750
4	1·160	24·00	12·00	21·000	29 000	44 000	43·000	14·750	13·000	11·000	13·000	13·000	13·000
5	0·639		2·00	4·000	4·250	5·680	2·720	5·000	3·740	4·000	3·830	3·920	3·820
6	1·375	32·90	9·68	16·540	17·910	19·710	11·020	18·910	11·860	11·820	11·360	17·950	16 610
7	0·900		17·65	17·840	16·380	26·280	15 000	34·750	36·390	24·000	17·320	21·230	25·750
Totals ...	Mean 0·827	112·11	81·64	110·617	129·580	199·946	129·349	146·122	120·929	100·270	96·955	110·864	114·662

Mean: 0·827 acres per million gallons.

$$\frac{\text{Total acres cleaned in 12 months}}{\text{Total area}} = \frac{1453}{161\cdot9} = 8\cdot96 \text{ times cleaned per year} = \text{once in 40 days.}$$

DISCUSSION ON THE PURIFICATION OF WATER.

Mr. T. D. Evans (Member) said it gave him great pleasure to propose a vote of thanks to Mr. Hughes for his valuable paper, although he was somewhat surprised at being asked to undertake the duty, as he had not come prepared with any criticism, not having had the opportunity of reading the paper beforehand; the author unfortunately having been unable to deliver the manuscript until the morning of that day. As to the covering in of filter beds, in the speaker's opinion it was not necessary, as most of the similar works in England were uncovered, although on the Continent, and in America especially, he knew covering in was very general. The rate of filtration mentioned by Mr. Hughes he regarded as excessive; it should not exceed 200 gallons per square yard per diem; slow rates gave more efficient results than high rates. Pressure filters required more head on them than those of the ordinary kind; he knew of one type taking eight feet, and it had also been found that unless the battery was carefully arranged, one filter affected another in working, so that the rate of filtration would be different in the two. To get the best results with pressure filters, coagulation and sedimentation must be carried out first, and this led to extra cost. He considered that Leighton Buzzard sand was the best medium for use in filters. Copper sulphate had been successfully employed by the Newport (Mon.) Corporation, in clearing their reservoirs of algæ; a paper describing the process was read some time ago by Dr. Jones, and a copy of it appeared in "Water."

Mr. J. N. Boot (Member) expressed the pleasure he felt in seconding the vote of thanks, and remarked that the members were somewhat at a disadvantage in not having a copy of the paper before them; for it so bristled with figures that it was impossible to do justice to it in the discussion without having seen a copy. One observation, however, had struck him; and on this point he did not agree with the previous speaker; it was that the author advocated closed in reservoirs. In his (Mr. Boot's) opinion, there should be no doubt whatever upon this,

and no need to advocate closing in. He regarded it as an absolutely necessary feature of construction, and that this view was general was proved by the fact that in all parts of the country uncovered reservoirs appeared to be the exception. Referring to the metropolitan water supply, he considered that, taking all things into account, and the many difficulties to be overcome, the inhabitants of London might congratulate themselves on having supplied to them water which was one of the purest, if not the purest, in the country.

MR. J. G. MOON (Member), after complimenting the author on his interesting and instructive paper, considered that the question of the purity of water was viewed by the manufacturing engineer principally from the point of view of whether the water he was using was suitable for steam raising without injury to his boilers. He had hoped that the paper would have dealt with the purity of water from this standpoint, as he was in charge of a battery of boilers, the water available for which was of 38° hardness, 21° being temporary hardness. The water threw down in the boilers about 1½ cwt. of solid matter per week. The processes of water softening were thus of great importance, and he desired to ask Mr. Hughes if the softening of water with lime and soda as usually adopted had any deleterious effect on the water so far as its use for drinking and general domestic purposes was concerned. He also referred to the action which marble had upon water with which it was in contact.

MR. F. D. NAPIER (Member of Council) added his thanks to the author for his paper, but regretted that the usual advance copies had not been available, as it was very difficult to follow Mr. Hughes' figures. Among the various filtering media mentioned, burnt ballast did not appear. In a district with a clay soil it proved a very cheap filtering material, and was largely employed for sewage filters. It might be possible to use it for the rough filtration of water. For small filters in connection with water softeners for boiler feed, the speaker very much preferred wood wool to sand, as the latter was apt to be carried over into the hot well, and pumps had been damaged through it. Makers of softening plants always repudiated this statement, and no doubt the sand getting into the hot-well was due to careless manipulation, but such accidents did occur from time to time,

and the only sure way to prevent them was either to avoid sand altogether or pass the water through a wood wool filter after it had left the sand. The wood wool could be washed when dirty and used several times over if considered necessary. If caustic soda were used to soften water for boiler feeding, great care should be exercised to avoid very slight quantities of the reagent being carried over into the boiler, as the action was cumulative, and he knew of some boilers that had been absolutely ruined by such treatment. If he might refer to Mr. Moon's inquiry he would say that there was no doubt that any reliable softener would reduce the water he mentioned to 3° and 4° of hardness. As an example, he might mention a certain water containing 53° of hardness which was reduced to between 2° and 3°, and the cost was about 2d. per 1,000 gallons. Water containing far greater proportions of impurities had been successfully treated, and it was only a question of installing some suitable apparatus that would mechanically add the exact proportion of reagent required to effect the chemical action, and allowing the treated water to remain long enough for the action to take place.

MR. J. J. LASSEN (Visitor) in expressing his thanks for the paper said he knew from personal experience how difficult it was to make a treatise on the subject of water purification interesting to an engineering audience, as it was necessary to constantly refer to chemical formula and symbols with which engineers could hardly be expected to be very familiar. He would have liked the author to have treated the question of water-softening somewhat more fully. This particular branch of water purification was one which was receiving more and more attention, and it was well known that there were now many excellent machines on the market for softening water for industrial purposes. It was a question whether the time would not come when the authorities of large towns would have to consider the desirability of softening the whole supply of town water. He mentioned that London water contained, in the form of hardness, 60 tons of lime for every day's supply. There was no reference in the paper to the de-oiling processes, both chemical and electrical, which were now coming very much to the front. The latter, although being somewhat more expensive than the former, was perhaps more efficient.

MR. W. C. WEDEKIND (Member) said he would like to know

what the author's experience had been in the use of coke as a filtering medium, as he had recently been engaged in the investigation and testing of a new filter in which that material formed the principal medium of filtering the water. The filter consisted of two concentric cylinders, about 13 feet high, built preferably of concrete, the outer being about 13 feet diameter and the inner 4 feet. The filtering medium was placed in vertical layers, *i.e.* rings, between the two cylinders and consisted of coke, sand, and shingle. The sand was only used to retain the water for the desired period within the coke ring and the water was led to a circular trough on the top of the outer cylinder whence it passed down pipes provided with very fine slots, into the coke. It then passed through the coke and sand into the interior of the inner cylinder which was provided for the purpose with a number of small drain pipes. These pipes not only allowed the water to pass out, but also permitted air to pass in, so that the filtering medium was constantly being supplied with fresh air necessary for the bacteriological purification of the water. It was necessary to observe that all matter in suspension was eliminated before the water reached the coke, as the latter served the purpose not merely of mechanical filtration but also purified the water of organic matter in solution and of germs. It had also been proved by very long and careful investigation that the coke had the effect of softening the water. In the case of one filter the charge was left undisturbed for eleven months, at the end of which period it was found that 50·49 per cent. of the organic matter in solution had been removed. A remarkable feature was that two days after the filter was recharged it was found that 54·56 per cent. of the organic matter had been removed, showing that the filter acted at once. The coke, furthermore, had the property of oxidising the iron salts in solution and of forming insoluble hydrates and, especially, of converting the magnesia salts into insoluble silicates. It was the magnesia which acted with the lime to form the incrustation of boilers; by separating the magnesia the cause of incrustation was removed. He was now carrying out tests on a second installation with a view to the softening of hard water, and although he had not yet received the full analytical tests, the improvement of the water was very remarkable. By a certain modification of the apparatus he even looked forward to the

removal of chlorine, although that might appear to be very ambitious, by splitting up the chlorine salts of magnesium and calcium and forming silicates, which being insoluble would be precipitated in the coke layer. The capacity of the filter of 13 feet diameter was 60,000 gallons in 24 hours, and, considering the small area occupied, the quantity was very considerable. The coke could not be washed and used again as sand could, but as a set off against that disadvantage it did not require the frequent and costly removal that sand did, and it could still be used as fuel. Both as a purifier and in cost of working, coke, when suitably employed, was far preferable to sand. This was owing to the fact that coke was a chemical laboratory in itself, and had the property of absorbing from 70 to 80 times its own volume of ammonia and nitric acid gases and of condensing them, amongst other equally remarkable properties. Indeed, the material improved very considerably on closer acquaintance.

THE CHAIRMAN, in closing the discussion, said that he sympathised with those of the speakers who regretted that the author had not confined his paper either to the purification of water for manufacturing or for water supply purposes. He was glad to see that Mr. Hughes advocated so strongly the vaulting in of filter beds and reservoirs. The vaulting over of such works had great advantages, and was almost imperative in all countries where wide ranges of temperature fluctuations were met with. The water was by this means protected against frost and extreme heat; it had, therefore, a more equable temperature throughout the year. The action of frost on the filter surface caused great difficulties in the cleaning operations and the open filters were more liable to become clogged by atmospheric impurities. In considering the question of frost, there were also the evil effects of ice in the exposed walls, rendering them liable to become cracked and leaky. The construction of vaulting in was not expensive when all the advantages gained were well considered. The extra cost was shown by the following figures of the water-works of Berlin and Warsaw:—the actual cost of vaulted filters was £3 to £3 10s. per square yard as compared with the estimated cost of £2 to £2 10s. for open filters. Sedimentation, previous to filtration was highly desirable. This should be carried out in long galleries on the continuous system, the water flowing at a very slow velocity. This would remove about 80

to 85 per cent. of the solid matter in suspension, leaving only 20 to 15 per cent. to be dealt with by the filters. The life of the filters was thereby greatly increased.

In regard to the depth of the sand in filters, practice had altered greatly in the last years, as the underlaying with fine and middle coarse gravel had been given up and sand substituted.

He did not believe that mechanical filters were to be recommended, a conclusion he had arrived at from the experience which had been related to him by an eminent American waterworks engineer. Such filters might, however, be advisable in countries where the natives, who had to be employed in cleaning the filters, could not be trained to habits of cleanliness.

Mr. Moon had raised a question as to the effect of marble on water, and with reference to it he (the Chairman) thought that it might be interesting to the members if he referred to what had occurred at Frankfort-on-Main. The groundwater supply of that city was found to have a most injurious effect on the walls of the pipes and of the concrete reservoir. It was first thought to be due to the small quantity of iron contained in the water, but afterwards it was traced to the free carbonic acid gas (3 parts per 100,000). After various experiments it was decided to aerate the water, passing it over a filter containing marble. This had the desired effect of absorbing the greater part of the gas and the hardness of the water had increased from $1 \cdot 5^\circ$ to $3 \cdot 3^\circ$. The cost of consumption of marble was about 1-10th of a penny per 1,000 gallons. The question of hard and soft waters was a favourite point of dispute of hygienic advocates. London had a hard water supply and the lowest death-rate of any large city. On the subject of the effect of water supply on the health of the population he would refer the members to the beautiful diagrams published by Mr. Lindley in his Presidential Address (Transactions, Vol. XV., page 37), where the decrease of typhoid was so clearly demonstrated. He thanked the author for his paper and considered it was a useful sequel to his previous paper on "Waterworks Construction."

The vote of thanks having been put to the meeting, was carried by acclamation.

MR. GEO. H. HUGHES, in replying to the discussion, said he wished first of all to express his deep regret at not having completed his paper in time to enable preliminary copies to be

operation of cleaning, he might state that manufacturers readily guaranteed to supply any make-up sand for a number of years, but he believed in no instance was any sand required upon examination of the filters. The amount of sand was found after a number of years' run to be the same as when the filter was first started.

The author thanked Mr. Lassen for adding to the value of the paper by his remarks. It must not be forgotten that the vexed question of softening the whole of a city's supply had two sides to it. The saving of soap and boiler cleaning was in its favour; whilst on the other hand soft water did not contain a large percentage of lime, which young children and those up to twenty-eight years of age in the bone forming period required. Bow-legged children and weak-kneed horses were examples of want of lime either in water or food.

He had been obliged to delete from his original draft reference to the de-oiling process, owing to limitations of length of the paper.

In reply to Mr. Wedekind he had used coke as a filtering medium, and as it was a material easily obtained and useful as a fuel after it had become choked and useless for filtration, he had no hesitation in recommending it where sand was not available except at a very high price; but considering that a porous material in masses could not be readily, if at all, made clean, sand was certainly to be preferred. The chemical properties referred to were of great interest, and the author expressed the hope that full particulars and results would be furnished to the Institution by Mr. Wedekind when he had completed his experiments.

In reply to the Chairman, the author was glad to have his support as to the covering or vaulting of filters, as well as of pure water reservoirs, and desired to thank him for his valued remarks of costs at Berlin and Warsaw. He regretted that the Chairman was not in favour of mechanical filters, but believed that with fuller knowledge he would be able to admit that they possessed advantages over the old type of filter beds, with their slow process of cleaning, &c.

He concluded by expressing his acknowledgments to the mover and seconder of the vote of thanks for their appreciative remarks, and to the members for the way they had received them.

printed as usual. Circumstances, however, had arisen since he promised to prepare the paper, which had rendered it very difficult for him to give the necessary time to it.

In reply to Mr. Evans he was still of opinion that the covering in of filters and filtered water reservoirs was desirable, both to secure freedom from after pollution, and to maintain as low a temperature as possible. He would refer Mr. Evans to a paper by Mr. Baldwin Latham and Professor May, which was read some twenty years ago, on the effect of temperature of potable water on the public health. The author was aware that copper sulphate as an algæcide had been applied at Newport, Mon., and he would add that at the Gloucester Impounding Reservoir in the Spring of 1906, the same treatment was found to be efficacious.

Referring to Mr. Boot's remarks he was glad of his support in regard to the covering in of filters, and agreed with him that the inhabitants of London had cause to be thankful for their splendid water supply. To render it as perfect as practicable should be the aim of all.

Replying to Mr. Moon, he regretted that the time and restrictions for one paper did not admit of dealing at any length with the softening and purification of water for manufacturing purposes, but he would refer Mr. Moon to an excellent paper read before the Institution of Mechanical Engineers on "Water Softening Plants." The lime and soda process was not deleterious to steam boilers providing that sufficient care were exercised in testing the water after treatment. The manufacturers of the plant usually gave simple instructions and materials for testing the results, and for adjusting the quantity of lime and soda, so that no excess or alkalinity occurred.

In reply to Mr. Napier, the author had had no experience in the employment of burnt clay ballast as a filtering media for potable water, but he could speak of its satisfactory use in filtering sewage effluent in conjunction with land irrigation. As to any sand being washed over into the hot wells, and causing injury to pumps, this was the first complaint of that nature he had heard of; it was an important matter and would no doubt be taken careful note of; possibly in the case referred to the sand was not suitable, and some of it was too low in specific gravity. As evidence that the sand was not washed away in the

CORRESPONDENCE ON "THE PURIFICATION OF WATER."

MR. WILLIAM PATERSON (Member) writes:—Unfortunately I was unable to be present at the reading of the paper by Mr. Hughes. From perusal of the proofs received, it is apparent he has made another valuable addition to the Transactions of the Institution. In response to his request for a description of my gravity filter, I send herewith a vertical sectional elevation of the apparatus (Fig. A) which will indicate generally the features of its construction.

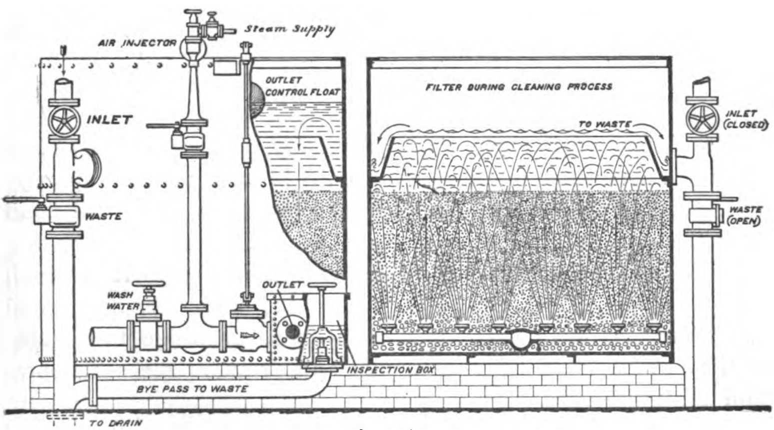


Fig. A.

The impure water, after mixture with the coagulant, if such be necessary, enters by the inlet valve into the distributing trough, and after percolating through the quartz sand is drawn off uniformly by a large number of gun metal strainers screwed into the manifold pipe system, communicating with the main outlet duct. This filtered water passes through the outlet controller and inspection box, overflowing to the pure water tank or mains. When the filtered bed becomes fouled with impurities and is unable to pass the required amount, the quartz is cleansed in a few minutes by first agitating with compressed air from the steam jet air injector, which is supplied and fitted with the apparatus, and then floating the loosened impurities over into the drain by a reverse current of cleansing water. The com-

pressed air ensures very thorough agitation, and dispenses with the need of agitator arms penetrating the filter bed. The accompanying Fig. B shows the detail of the strainer system and how readily the bronze screens are renewed.

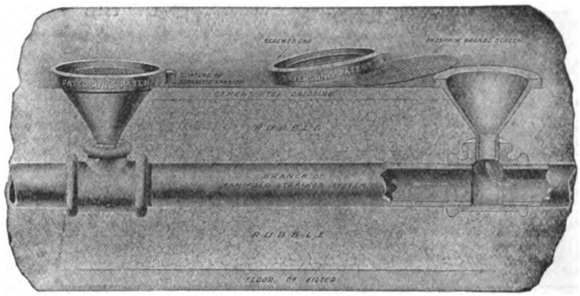


Fig. B.

The author of the paper will no doubt agree that one of the great advantages of sedimentation tanks is their storage capacity, which can be drawn upon in time of drought or flood. At flood time the opportunity is often taken by local authorities, manufacturers and others, to get rid of accumulated impurities which they would not dare to discharge into the stream in its normal condition. At such times it is a distinct advantage to be able to dispense with the stream supply and draw on the sedimentation tanks.

Referring to the reduction in hardness due to storage at Staines, the figure columns for 1903 and 1905 are headed "Raw" and "Stored" respectively, making it evident that the waters were originally the same, but the columns for 1906 are headed "Thames Water" and "Staines Water," and the text refers to them as "typical Thames water after short storage and filtration, and filtered Staines stored water." Were these waters originally the same? Is so, why not designate them "Raw" and "Stored" as before, and what accounts for the hardness reduction of 50 per cent. in 1906, as compared with 25 per cent. in 1903 and 1905? If they were originally identical, the result is remarkable. If they were not, there is no justification for the claim of "a reduction due to storage, of 50 per cent. in hardness."

The author will possibly agree with me that it is not necessary

to have 3 feet of gravel supporting the sand. As a matter of fact, it is immaterial how thick the layers are, so long as there is a layer of each grade at every point. Three layers each 4 inches thick is, in my opinion, quite sufficient. Finely crushed marble as filtering medium tends to harden the water, and for this reason is objectionable, unless the water is exceptionally soft and hardening is advantageous.

When dealing with mechanical filters the author gives the rate of filtration of mechanical filters as 2,222 gallons per square foot per twenty-four hours. This is equivalent to 92 gallons per square foot per hour and a very safe figure. I have known cases where mechanical filters have been rated at 300 gallons per square foot per hour, and consider this most excessive.

In regard to the amount of alumina required for coagulation, which the paper gives as about 0·5 of a gram of sulphate of alumina to the gallon, this is equivalent to 7·5 grains per gallon. In many cases under my notice, the amount of coagulant required for really bad waters is only 1 to 2 grains per gallon. Much depends on the nature of the other impurities present.

The author asserts that on a large scale where space is available, the intermittent process of water softening is best. With proper measuring gear and sand filtration, the continuous softening process can effect as high a degree of purification as it is possible to secure. Certainly better than can be obtained by the intermittent process, where precipitation is relied upon for the final purification.

MR. C. W. PETTIT (Member of Council) writes:—I am glad of the opportunity to give expression to my appreciation of this welcome and valuable addition to the author's previous paper on "Water Supply." He has not yet exhausted the subject, and I hope he will find time in the future to make further contributions to our Proceedings.

The practice of creating large stores of water, which originated in the desire to provide for the dry days during the rainy ones, is unquestionably a wise one, since it also serves the purpose of increasing the purity of the supply and facilitates the process of filtration. I am not so sanguine as the author with regard to the future of rapid mechanical filters, and do not see where the

economy in cleansing comes in if the value of the water required for this purpose is taken into account, but I believe it seldom is. The quantity of wash water required for cleansing in mechanical filters is, I understand, equivalent to about 7 per cent. of the quantity filtered, whereas in slow sand filters it should not exceed on the average $\frac{1}{5}$ per cent., although I believe it is sometimes as high as 1 per cent. where the sandwashers are of an inefficient type. To this must of course be added the cost of labour in skimming the beds, and replacing the washed sand, &c., but even when taking this into account the result is in favour of the slow filters on the question of cleansing.

I have not yet been convinced of the efficiency of rapid mechanical filters, which I consider should be regarded rather as strainers for use only where the water has been stored in large reservoirs and already become practically pure.

The author limits the rate of filtration in ordinary gravity filters to 500 gallons per square yard per 24 hours. Should this not be dependent upon the condition of the water to be treated? It has been stated that at Zurich where the water is comparatively low in bacteria, good results have been obtained with a filtration rate of over 2,000 gallons per square yard per 24 hours, but even this does not nearly approach the speed attained in mechanical filters. I am interested, and would be glad to know if there is any special property in mechanical sand filters which permits of such a rapid rate of filtration, and whether the results of purity tests are really reliable and as satisfactory as claimed.

I do not agree with the author as to the suitability of Hayle sand for filtering media. A sample I have by me consists entirely of small particles of shell, not a grain of silica being visible, but perhaps there is another description of Hayle sand with which I am not familiar.

With reference to my sand washing apparatus, at the author's suggestion I have pleasure in sending the following description of it, and also two views illustrating its construction :—

The sand as it comes from the filter beds is placed in the ejector tank A, shown at the foot of the apparatus, from which it is elevated by an hydraulic sand-ejector B, and delivered into the head of an inclined zig-zag troughing C. As the sand with water flows down this troughing it is constantly agitated by a series of wiers and breakers, which disintegrate the foreign matter adherent

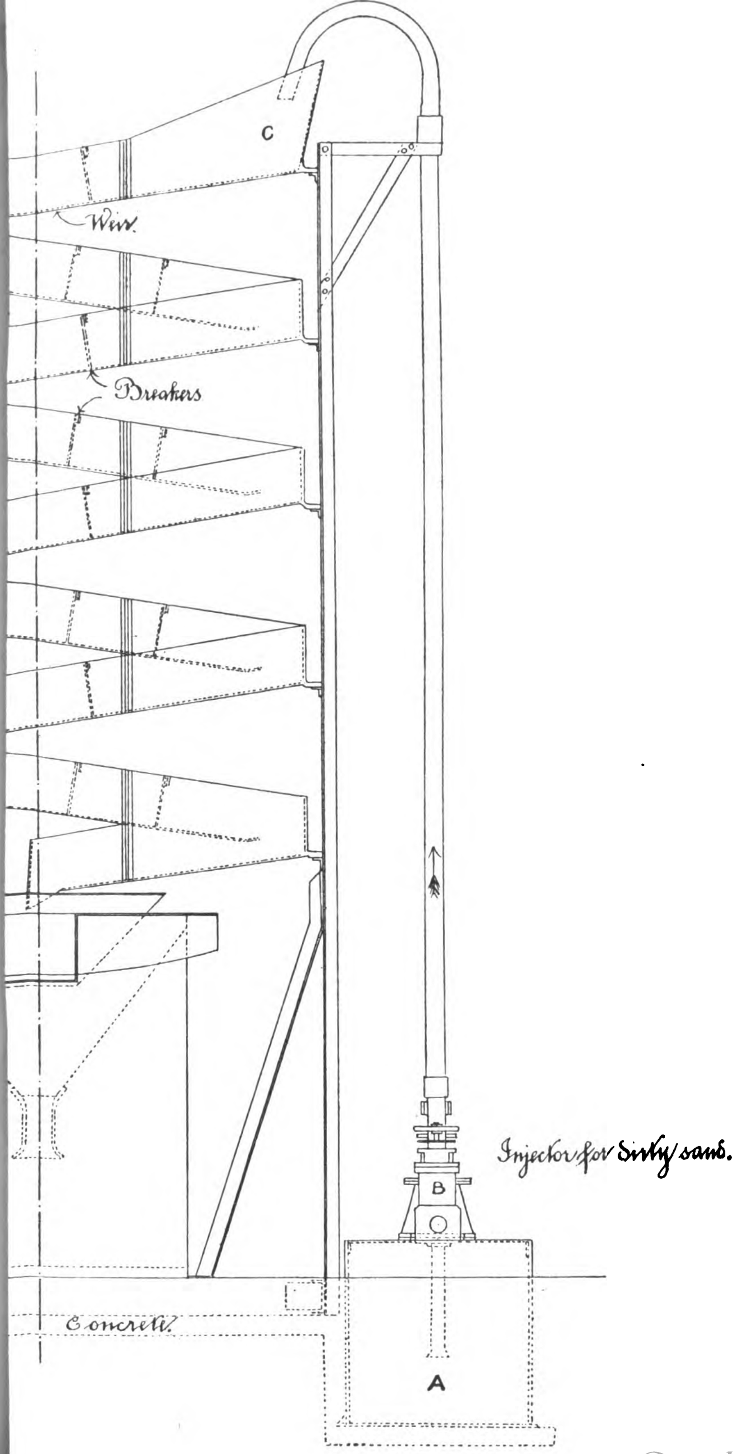
to the sand before it arrives at the upper cone D. This cone causes the mixture of sand, dirty water, and foreign matter to flow downward until it meets with a stream of clean water flowing upwards at a regulated speed through an aperture K in the diaphragm cone J between the lower or clean sand chamber and the hopper D above, which permits the clean sand only to continue falling downwards through the aperture K into the clean sand chamber E, while the dirty water and foreign matter are carried upwards and discharged into the annular overflow channel F, and thence away to a drain.

The sand in passing downwards against this upward current of clean water, receives a thorough rinsing, and is discharged from the clean sand chamber through the pipe G by means of an hydraulic ejector H. It will be noticed that the apparatus is simple in construction, has no moving parts to get out of order, and but few parts subject to any appreciable wear, these being insignificant in value and easily replaced; the space occupied is small, and it can be constructed so as to be portable if desired. Whilst the output is large for the size of the apparatus it requires but a small volume of water for efficiently cleansing the sand, and while regularly fed, requires no further attention when once started.

The original machine was used by Messrs. John Aird and Sons, in the construction of the New Waterworks at Kempton Park for the Metropolitan Water Board, and washed upwards of 40,000 tons of sand for filtering media during a period of six months, being an average of 300 tons per diem, so that the principle on which the machine has been constructed has been thoroughly and practically tested in actual and extensive work with most satisfactory results.

As to the results of the apparatus, its efficiency has been recently proved by an official trial of a new installation at a water works where very dirty filter skimmings were satisfactorily washed with an ascertained total expenditure of only 1,400 gallons of water per cubic yard of washed sand. The machine illustrated was designed to wash 5 cubic yards of sand per hour, but much larger quantities can easily be dealt with. It may be added that a large plant is now being installed at the Metropolitan Water Board's Works at Thames Ditton for dealing with 100,000 cubic yards of raw material to obtain the filtering media for the new filter beds

being constructed there. For situations where high pressure water is not available, a modification of this machine is employed, in which the hydraulic ejectors are replaced by mechanically driven bucket elevators. A machine of this type has been in use for some time at the extensive sand pits at Leighton Buzzard, and has an average output of approximately 100 cubic yards of washed sand per diem.



C
Weir
Breakers
Injector for Dirty sand.
B
Concrete
A

SEWER DESIGN.

The Ninth Meeting of the Twenty-seventh Session was held at the Royal United Service Institution, Whitehall, on Tuesday, 12th May, 1908, the attendance being 92.

Mr. Geo. T. Bullock (Vice-Chairman) took the chair at 8 p.m., and the minutes of the previous meeting were read, confirmed, and signed.

It was reported that, since the last membership announcement, the following had been elected to the Institution :—

Vice Presidents.

Sir William Huggins, K.C.B., O.M., D.C.L., LL.D., F.R.S. ...	London.
Sir Archibald Geikie, K.C.B., F.R.S.	Haslemere, Surrey.
Professor J. J. Thomson, F.R.S. ...	Cambridge.

Honorary Member.

Professor John T. Nicolson, D.Sc., M.Inst.C.E.	Manchester.

Members.

J. S. Kodandarama Aiyar ...	Mayavaram, India.
William Ernest Baker	South Ealing.
William Myles Howard Ballantyne	Streatham Hill.
William Addison Bradley ...	Margate.
William John Conn	Beaufort, British North Borneo.
Andrew Wallace Cowan	Blackheath.
Frederick John Crabbe	Sheerness.
Theodore Dent	Consett.
Leopold Edwards	Wandsworth Common.
Leonard Rothery Ellis	Birmingham.
Stanley William Ellis	Walton-on-the-Naze.
Ronald Joseph Francis	Crouch End.
John Alexander Hamp	Neasden.
John Hay	South Hampstead.
Louis Thomas Healy	Lewisham.
Oscar Fridolf Alexander Sandberg	Westminster.
G. Venkatachala Srinivas ...	Benkipur, S. India.
Allen Vickers	Battersea.
Harry Williamson	Bahia Blanca, Argentine.

Associates.

Godfrey Arblaster	... ...	Birmingham.
Owen Davies	... ...	Birmingham.
Reginald Lloyd ...	... ...	Birmingham.
Stanley Graham Neustead	...	Cricklewood.
Rimington Osburn	... ...	Lee.
M. S. Ramaswamiengar ...	...	Jalgaon, Bombay, India.
Edward Seldon ...	... ...	Herne Hill.
Lawrence Edward Standley	...	Walton-on-the-Naze.
Robert Schofield Swithenbank	...	Catford.
Cyril William Tomlinson	...	Woking.

Moved from the chair, it was resolved by acclamation, that as the Sixtieth Anniversary Celebrations of the Institution of Civil Engineers of France were now proceeding, a telegram in the following terms be despatched:—"President, Council of Junior Institution of Engineers, offer heartiest congratulations on the Sixtieth Anniversary of your Institution.—Gustave Canet."

This meeting of the Institution being the first held since the announcement in the Journal for May of the Durham Bursary, the following resolution moved from the chair, seconded by Mr. E. F. Heron, and supported by Mr. Francis R. Taylor, was passed by hearty acclamation:—

> "That the cordial thanks of the Junior Institution of Engineers be conveyed to Mrs. Frank R. Durham, for her generosity in founding an Annual Bursary, which, besides affording evidence of her kindly interest in the welfare of the Institution, may be the means of enabling some of the younger members to rise to a greater degree of usefulness in the profession to which they belong."

A paper on "The Design of a Sewer," was read by Mr. Frank R. Durham, Assoc.M.Inst.C.E. (Chairman of the Institution).

Mr. Ronald Francis opened the discussion and proposed a vote of thanks to the author for his paper, which was seconded by Mr. Allen Vickers and cordially adopted.

The other speakers were Messrs. G. H. Hughes, R. S. Lindley, P. J. Waldram, Reginald Marshall, C. T. A. Hanssen and L. H. Rugg.

The author having replied, the proceedings terminated with the announcements of the visit on the 16th May to the L.C.C. Southwark and Bermondsey Storm Relief Sewer Works; the visits on 23rd May to the Avonmouth Docks Works, and Bristol Electricity Works; and of the Summer Meeting in France from 27th June to 11th July.

Part 10. **JULY, 1908.** **Vol. XVIII.**

The Junior Institution of Engineers.

(Incorporated.)

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

6th July, 1908.

ANNOUNCEMENTS.

SATURDAY, 27th June to 11th July. Summer Meeting in France, the party assembling in Paris on Saturday evening, 27th June.

THURSDAY AFTERNOON, 16th July. Visit: The New Luton Works of the **Davis Gas Stove Company.** *On this occasion the invitation is extended to ladies.*

Membership.

VICE-PRESIDENT. The Council have the honour of announcing the election of SIR ROBERT ABBOTT HADFIELD, M.Inst.C.E., Hecla Foundry Steel Works, Sheffield, as a VICE-PRESIDENT of the Institution.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

BRUCE-KINGSMILL, JULIAN; Messrs. E. S. Hindley and Sons, 11 Queen Victoria Street, London, E.C.

CROFT, CYRIL MURTON; care of Mr. H. E. Jones, Palace Chambers, Westminster, S.W.

Proposed for election to the class of "Associate."

TOOGOOD, GEORGE WATTS; London and North-Western Railway Works, Crewe.

Appointments.

231. Young Civil Engineer desires engagement, home or abroad; good technical education, three years tube railways experience, two years practical training on tramway construction, conduit and overhead systems; excellent testimonials.

232. Member, age 21, desires engagement at home or abroad as draughtsman or assistant engineer in electrical or mechanical engineering; seven years shop and drawing office experience.

PERSONAL NOTES.

STAFFORD X. COMBER left Messrs. S. Pearson and Son, Ltd., upon the completion of the East River Tunnels, New York. He is now with the McArthur Brothers Construction Company, of Chicago, on their contract for the Main Dams for the Ashokan Reservoir in the Catskill Mountains. Address, Ashokan Camp, near Brown's Station, Ulster and Delaware Railroad, U.S.A.

A. H. DOWNES-SHAW is now in the Drawing Office of Messrs. Heenan and Froude, and has been appointed on the staff.

F. G. FORD is serving as second engineer on the s.s. "Satsuma," trading between New York, China and Japan.

S. HUNTER GORDON who was with Messrs. Vickers Sons and Maxim, Barrow-in-Furness, has become Manager of the Rose Street Foundry and Engineering Co.'s Works, Inverness. Home address, 24 Hill Terrace, Inverness.

ALFRED HURSE has returned to England.

R. T. PATERSON has returned home after seventeen months in the service of the African Ore Concentrating Syndicate, Ookiep, Namaqualand, South Africa.

L. W. PUGH is now with the West Ham Corporation at their Electric Generating Station, Canning Town, E.

HAL WILLIAMS is to act as Rapporteur for section "D" of the forthcoming International Congress of the Refrigerating Industries, to be held in Paris, and is to read a paper on "The Design and Construction of Cold Storage Premises."

CORRESPONDENCE.

THE TRAINING OF ENGINEERS.

MR. A. H. DOWNES-SHAW, of Messrs. Heenan and Froude, Ltd., Worcester, writes:—I have read with great interest Mr. Swain's remarks in the June issue on this subject. It is undoubtedly a matter to which the Junior Institution of Engineers should give special attention.

Mr. Swain suggests that the Institution should collate the ideas of different people, sift them out, and "promulgate standards of training for the various branches of the profession." This, however, would be a very big undertaking. There are already many standards on record. Each university and technical college has one of its own. Generally speaking, these institutions have spent years in studying the needs of their own localities, and their schemes provide just what is wanted by the particular industries about them.

At the same time, opinions as to the exact use of a technical graduate—or the advantage in commercial life which a college training gives—seem to be rather vague. Many graduates write to the papers in disgusted fashion, and complain that their technical training has not brought them anything like the number of good things they were led to expect from it. Again, we find, on the one hand, heads of firms on the college councils encouraging these schemes for all they are worth, and, on the other, foremen, draughtsmen, and members of staff generally—men who can often influence the junior appointments—decidedly shy of the university man. I would suggest that the whole matter might first be thrashed out at one of our ordinary meetings. "The Training of Junior Engineers" would make an ideal subject for an Honorary Member's lecture. The Honorary Member might be a professor, and if a good show of employers and managers (particularly the latter) could be found to take part in the discussion, we should get an expression of opinion that would be most valuable to engineers generally. We might then see more clearly on what lines we ourselves should set to work.

THE PURIFICATION OF WATER.

MR. WILLIAM PATERSON (Member) writes:—There are many interesting points raised in the discussion on the Purification of Water (page 509 *ante*), which no doubt Mr. Hughes will reply to fully, but Mr. Napier's remarks (page 510) I cannot pass without comment. He appears to have been particularly unfortunate in his experience of softening and purifying apparatus. A quartz sand filter of defective construction will undoubtedly, pass the sand, but no first-class filter will. The strainer system, as illus-

trated in Fig. B, page 518, eliminates all possibility of the sand getting through with the filtered water, even with the most careless handling, for the simple reason that it is impossible for it to do so. The highest class machines are fitted with wood fibre strainers for the preliminary, and with quartz sand filters for the final purification. Such filters, from 500 to 35,000 gallons hourly capacity, have been installed at H.M. Dockyards, Pembroke, Gibraltar, Chatham and Portsmouth, at the Royal Arsenal, Woolwich, at various well known engineering works, and at over one hundred of the most modern power stations in the country. These purifiers discharge directly into the feed-pump suction tank, and in no single instance has any complaint been received of the quartz sand coming through.

FROM THE STARTING PLATFORM.

AN IMPRESSION OF FRENCH ENGINEERING.

"What do you think of French Engineering?" is the question which will no doubt often be put to those Juniors who have been fortunate enough to take part in the Summer Meeting of 1908. The exact reply which each Junior gives will naturally depend upon his own particular professional point of view, and upon the degree of experience he can bring to bear on the making of comparisons. For my own part, I have formed a great admiration for the initiative and the enterprise which mark the French Engineer. The energy with which he attacks a new problem, the intelligence he brings to bear on its solution are to be seen in many directions, and it is only necessary to quote the pioneer work and the subsequent progress of our neighbours in the field of motor traction and aeronautics to emphasise the extent to which these characteristics prevail. The artistic temperament of the French, as a people, is proverbial; that it should permeate their engineering work is but natural. A survey of their roads and bridges, their planning of public places and buildings, and even their designs for factory buildings, reveals the soul of the artist dominating the brain of the architect or the engineer, at least to the extent of assuring that the acceptable, but not compulsory, element of

beauty shall be a feature of their work. Given these conditions, the visitor to France cannot but bring away with him pleasant impressions of his journey from the professional point of view, and I am sure that my fellow Juniors will cordially agree with me in this respect. Inside the various works good organisation appears to be the order of the day, and indeed the famous house of Messrs. Schneider, at Le Creusot, is a model of what careful management can achieve. An enormous works employing 15,000 workpeople, manufacturing almost everything from thin sheet iron to heavy armour plating, from a bullet to a 12 inch gun, from a donkey pump to a locomotive, a turbine to a 12,000 H.P. rolling mill engine, needs organisation of the highest class if it is to pay its way in competition with the open market. We found everything working like a clock, every department full of orders at competitive prices from nearly all the countries of the world, and the staff and workmen just one big happy family. In short, an industrial triumph of the most impressive kind.

As to the reception of our party and the arrangements for our visit, there is only one fitting word—magnificent. Even in Le Creusot, as in works of lesser import, it was a source of gratification to find that English engines and machine tools were installed in no small quantity. An instance of good judgment, this, which enables us to wish prosperity to our neighbours, with the best of hearts, for the more their industries extend, the more they may require to use British plant and tools. Le Creusot will long remain enshrined in the memory and the affections of the Junior Engineers, and so long as France can produce a Schneider, a Canet, an Eiffel, a Comte de Dion, a Farman, a Sauvage, and other engineers and experimentalists of like degree of enterprise and skill, so long will she remain a factor to be reckoned with in the march of engineering science.

PERCIVAL MARSHALL.

Paris, July 4th, 1908.

OBSERVATIONS IN GENERAL.

At the time of writing, the Institution's long-talked-of Summer Meeting in France is in full swing. Members and their fair friends are greatly enjoying all the good things, both technical and social, that have been provided through the invaluable influence and assistance of our President and the gracious interest of Madame Canet.

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It is a matter of the deepest regret to all that M. Canet is prevented by illness from being with "My Juniors," as he affectionately described them in a recent letter. He fully intended, right from the moment the meeting in France was decided upon, to go with them through the whole tour.

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We express most sincerely the hope that he may soon recover, and we offer to him and Madame Canet our sympathy.

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Messieurs Paul and Albert Canet have kindly undertaken to represent their father during the meeting, and right well are they doing so. They received the party on their arrival at the Gare St. Lazare, and are constant day by day in many attentions.

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In the recent list of birthday honours we noted for the distinction of Knighthood the names of our newly-elected Vice-President, Robert Abbott Hadfield, and Professor Alfred George Greenhill, Vice-President. The Institution presents its congratulations.

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Since our last number was issued two University events in which we are particularly interested have taken place.

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The first occurred on the 12th June, when Lord Rosebery was, in the Bute Hall, installed as Chancellor of Glasgow University, in succession to the late Lord Kelvin, whose memory as a distinguished scientist and as a Vice-President of our Institution we shall ever revere and cherish; whose place, to quote the words of Lord Rosebery, "cannot be filled by any living man."

The second was at Cambridge, on the 17th June, the occasion being the installation of Lord Rayleigh, O.M. (Vice-President of the Institution) as Chancellor of the University, in succession to the late Duke of Devonshire.

VISIT: PURLEY WATER WORKS.

WATER SOFTENING, PUMPING, &c.

The Fourteenth Visit of the Twenty-seventh Session took place on Saturday, 11th April, 1908, at 3 p.m., when the Water Softening and Pumping Plant at the Purley Station of the East Surrey Water Company was inspected under the guidance of the Engineer, Mr. A. E. Cornwall Walker, the attendance being 32.

At the conclusion of the visit afternoon tea was served in the engine room, and the Chairman (Mr. Frank R. Durham) conveyed the acknowledgments of the Institution for the courtesy with which the members had been received, Mr. Walker replying. The following particulars of the Works have been kindly furnished by him :—

Purley Pumping Station.—The Works were completed and put into commission during the latter part of 1902. They consist of an engine and boiler house, coal stores, workshops, smithy, administrative block and workmen's cottages, together with the softening plant.

The engines are of the compound beam type, each engine driving three sets of service (bucket and plunger) pumps, and one set of borehole (double-acting bucket) pumps. The three former pumps work under heads of 650 feet, 550 feet, and 400 feet respectively. The pumping plant is capable of dealing with about one and a half million gallons per diem, and is in duplicate.

Steam at 140 lbs. per square inch pressure is supplied from one of three Lancashire boilers, which are fitted with "Perret-Jouet" furnaces for forced draught. A Green's economiser is worked in connection with these boilers. The workshops contain various machine tools for repair and other work.

The water is derived from boreholes in the chalk, and has an initial hardness of about 17°, the softening process reducing this to about 3·5°, when practically the whole of the temporary hardness is eliminated.

Water Softening Plant.—The softening process is that commonly known as the Clark's Precipitation Process, and consists of the addition of lime water to the initial or hard water, the resultant precipitate being allowed to settle prior to the decanting off of the softened water.

The lime for the lime water is obtained locally, and is specified as "Flare Burnt Lime"; it is used in as fresh a condition as possible (the supply being a daily one). A sufficient quantity for one lime tank is weighed out, and then tipped into the "slaking" or "cream of lime" tank, where it is well slaked, thoroughly stirred and mixed to the consistency of thick cream, and at this stage is known as "cream of lime." As soon as this treatment is completed the cream is run off into a wire sieve, which is placed over a second tank, where it is again well mixed with an additional amount of water until it much resembles milk, and at this further stage is known as "milk of lime," when the preparation becomes ready for use in the lime tanks.

The lime tanks, six in number, are rectangular open tanks, constructed of concrete, and each have a working capacity of 46,000 gallons. Along the bottom of every tank there are a number of galvanised steam tube frames, each connected to a down pipe from off the main air supply pipe. In these frames there are a number of small perforations, through which compressed air passes into the tanks, thus agitating the water and insuring a thorough mixing of the particles of lime with it and also keeping these from settling to the bottom, until a saturated solution of lime water is obtained. The air for this purpose is supplied from a special compressor plant (which is in duplicate), at a pressure of about 5 lbs. per square inch. For the making of lime water it is essential that soft water shall be used; the lime tanks and softening tanks are therefore so arranged that a supply of soft water can be obtained by gravitation from the latter to the former. In the preparation of lime water the first procedure is

the filling of the lime tank with soft water, the milk of lime not being added until the tank is about two-thirds full of soft water. Just before the milk of lime is added the "agitating" is started, and continued for about an hour. The water in the tanks is then allowed to stand and clear, and later is decanted off, for the softening operations in one or other of the softening tanks. The bottom levels of the lime tanks and softening tanks are so arranged as to allow of the complete emptying of a lime tank into a softening tank.

The softening tanks, five in number, are constructed of concrete, and are similar in form to the lime tanks; each has a working capacity of 290,000 gallons. In a softening operation the lime water is first of all run into the tank; the hard water is then pumped in through a "grid" arrangement of pipes resting about 18 inches above the bottom of the tank—this multiple distribution ensuring a thorough mixing with the lime water. Immediately upon the hard water coming in contact with the lime water the softening operation commences, and at the same time the precipitation starts and continues during filling and for some considerable time afterwards, the chalk from the hard water and the re-converted chalk from the lime water being together deposited at the bottom of the tank. When the treated water becomes clear it is decanted off to the service pumps.

The faces of both the softening and lime tanks are rendered to ensure watertightness. The lime tanks require cleaning out about every three months, and the softening tanks every six months, according to the amount of water treated in them in the intervening periods. A complete record is kept of every operation in both lime and softening tanks, so that the treatment of any tank can be traced from start to finish. A daily test for hardness is also made at the Company's office. The great value of this process is in its positive nature, both chemically and bacteriologically, the water in each and every tank being tested for hardness and alkalinity before it is allowed to be decanted; and if necessary it can be subjected to further modification.

The bacteriological results from many samples show that the process is highly efficient, and one which could be relied on as a most valuable safeguard, should such be required.

"THE DESIGN OF A SEWER."

By FRANK R. DURHAM, Assoc.M.Inst.C.E
(Chairman of the Institution.)

Read 12th May, 1908.

Introduction.—In choosing the above subject for a paper, the author intends to try and deal with, in a concise form, some of the salient points to be regarded in the design and construction of a sewerage system, so far as it concerns the sewers themselves. The paper is not an encyclopædic description of all the various systems throughout the world, but is based solely on knowledge and experience acquired abroad. It describes some principles and methods which, if not entirely applicable, may be adaptable to all those countries where the Institution has its members.

The author feels it to be his duty, first of all, to express his gratitude for the kind way in which Mr. W. H. Lindley, Past-President of the Institution, has given him permission to write this paper, and publish diagrams and drawings of his own works.

The foremost maxim in designing a system of sewers is that it should not be conceived for present or immediate future needs, but with a view to the widest possible development in the future; thus the main lines of a system, once determined and provided for, should be capable of coping with the gradual increase of population and developments within the natural drainage area under consideration.

It will prove false economy to lay upon posterity the burden of having to reconstruct a whole system of sewers, when with a slightly increased initial cost, the whole future additional expenditure can be saved.

The result of want of foresight will be a patchwork system of sewers, or better said, a network of sewers without any system, a deplorable condition, alas so frequently met with in this country.

Sewerage Systems.

There are two distinct systems of sewerage; (a) the combined drainage system, and (b) the separate system.

(a) *Combined Drainage.*—In the combined drainage system the rain and household sewage are taken off together through one network of sewers by an "intercepting system," in which long main lines of sewers run more or less parallel to the contours, each sewer intercepting a district; or by a "radial" system, in which individual districts are drained by systems of radial sewers discharging either into a main trunk sewer or at a series of pumping stations for being lifted and forced to the outfall.

(b) *Separate System.*—In the separate system there are two distinct networks of sewers, one for the household sewage, with a modicum of rain water, and one for the rain water.

It is not the author's intention to examine critically the respective merits of each system, but he is of opinion that for large districts, or towns densely populated, the intercepting system with combined drainage is the correct one. For rural districts, small villages and the like, the separate system may be advisable from the financial point of view, provided that the rain water can be easily dealt with, either by surface drainage or by a cheap system of shallow rain-water sewers. It is a matter for very careful financial calculations and hygienic considerations to decide whether a combined drainage or a separate system is to be recommended.

The intercepting system of combined drainage will be taken as the basis of design throughout this paper, as all other systems are only modifications of it.

Quantity of Sewage.

Dry-Weather Flow.—The water consumption per head of the district or town to be drained will give the approximate dry-weather flow which a sewerage system will be expected to carry off. This figure, combined with the average density of the population, will determine the unit quantity per unit area. In calculating this per unit time, it will be advisable to remember that assuming the mean water consumption $= 1$, the maximum daily consumption equals the mean consumption $\times\ 1{\cdot}4$ and the absolute maximum rate of consumption $= 1{\cdot}4 \times 1{\cdot}5 = 2{\cdot}1$. In the case of large manufactory centres, a greater consumption of water must be allowed for; thus the dry-weather coefficient varies with the density of the population, and a greater value

must be adopted for a crowded centre than for a suburban district. These coefficients once obtained, multiplied by the various areas, will give in part and in whole the quantities of the dry-weather flow to be dealt with by each sewer.

Rain.—The provision for rain water in sewers requires most serious attention, and is by far the most difficult problem. The rains are divided into two distinct classes: *First*, the steady gentle down-pour falling during a long period of time and running off to the sewers with a more or less regular flow; and *secondly*, the sudden storm or cloud burst of short duration, causing a sudden inrush of a very large quantity of water. In estimating the rain quantities, a thorough study of the rain records of the locality or similar localities must be made, and tables of frequency of occurrence and intensity prepared and plotted.

The chief difficulty in dealing with heavy storms or cloud bursts is the scanty information obtainable, and the scarcity of automatic recording rain gauges registering in some form or other the rate at which the rain falls. It is quite clear that records from such instruments would greatly facilitate the determination of the quantity of water that must be provided for, and it is to be hoped that there will be a more general adoption of automatic registering rain gauges by the Governments and municipal authorities throughout the world.

It must be remembered that it will be found impossible to make provision for the most extraordinary rain falls. It would not be correct either from the financial or hygienic point of view to build sewers of a size capable of coping with the absolute maxima that may occur once in intervals of 25, 50, 100 or even longer cycles of years.

Those members who take special interest in this section of the subject, are referred to the interesting paper on the "Elimination of Storm Water from Sewers," read by Mr. D. E. Lloyd Davies, before the Institution of Civil Engineers in 1906.*

Wet-Weather Flow.—The coefficient for steady rain flow will depend greatly on the outfall conditions of the system and the

*Minutes of the Proceedings of the Institution of Civil Engineers. Vol. CLXIV., pp. 41-67.

prescribed requirements for the purification of the sewage. It is usually considered as being the dilution coefficient giving the quantity of sewage which must be dealt with prior to the rain overflows coming into action. In this country a somewhat higher figure than on the Continent is accepted, owing to the difficulties which exist in providing for a suitable and efficient outfall for the sewage effluents. Therefore the amount of water which it will be required to provide for will probably vary between four and six times the dry-weather flow before any rain outlets come into action. It should be determined from the rain records, be proportionate to the dry-weather flow, and have differential values in accordance with the density of buildings, the nature of the street paving, the areas of open spaces, parks, &c.

Storm Water.—For the calculation of the quantity of storm water there are a great number of formulas. The discrepancy in nearly all the formulas is the unsatisfactory determination of the time element, which makes practical equations very complicated. The author has always used the formula of Bürkli-Ziegler, although it cannot be called accurate, it is nevertheless a consistently safe one to use in practice, either in its original form or with some modification of the same.

$$Q = Rc \sqrt[4]{\frac{S}{A}}$$

Where Q = cubic feet per second per acre flowing to the sewers.

R = average rate of rainfall during the heaviest fall in cubic feet per acre.

c = a coefficient = 0·75 for paved streets and 0·31 for macadamised streets.

S = general grade of the area per thousand.

A = the drainage area in acres.

or in the modified form

$$Q = \frac{c\ A}{\sqrt[4]{A}}$$

The following values of c are subject to such modifications as are required by the actual rain records of the locality, and may be taken as :—

1·80 cubic feet per second per acre for densely built on flat areas with paved streets.

1·35 cubic feet per second per acre for ordinary built on sloping areas.

0·90 cubic feet per second per acre for suburban districts.

0·25 cubic feet per second per acre, for parks, gardens, railway goods stations, &c.

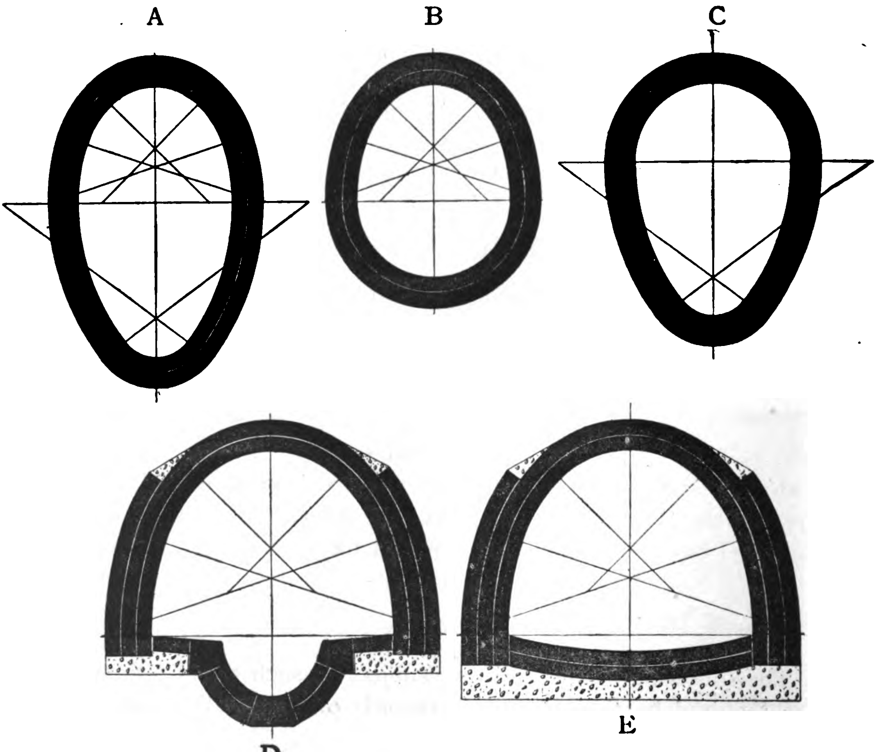
With a limitation that never less than ¼ of the accepted values should be taken, or

$$Q = \frac{c\,A}{\sqrt[4]{256}} = \frac{c\,A}{4}$$

SIZE OF SEWERS.

Profile.—Sewers are usually designed either with circular, egg-shaped, inverted egg-shaped, or bell shaped profiles (see Fig. 1.)

Fig. 1.—Sewer Types.



The *circular profile* is usually adopted for pipe sewers, storm outlets, or main trunk sewers, where large quantities of water are dealt with.

The *egg-shaped profile* (A and C) has evolved from the old barrel form with its semi-circular invert and vault with vertical sides. The egg-shape was adopted to obtain a more favourable hydraulic radius $= \dfrac{\text{area}}{\text{wetted perimeter}}$ and an improved velocity in the lower sections of the profile. The egg-shape is either constructed with a semi-circular or an elliptical vault. The latter is undoubtedly the best form ; it is stronger against earth pressure, it gives greater carrying capacity at very small additional cost, the cross section area being more than 15 per cent. larger ; and it is far more comfortable for inspecting, for the height of the smallest sized masonry sewers with semi-circular vaults (2 feet × 3 feet) becomes 2 feet × 3 feet 6 inches, when constructed with an elliptical vault.

The *inverted egg-shaped profile* (B) is used for big main intercepting sewers, where large quantities of dry-weather flow have to be carried off, requiring a larger lower cross section in order to reduce the depth of flow, and thus reduce the depth of the sewer itself below ground. It is likewise used for main outlet sewers, rain overflows and storm outlets.

The *bell-shaped profile* (D and E) is essentially used for storm outlets. The bell vault is often built over a main intercepting sewer, when the development of a town has increased to such an extent that additional cross section must be provided for the main sewer.

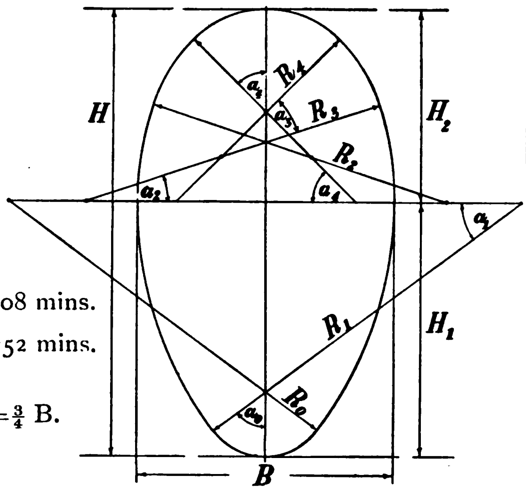
There are many other types of sewers, but it is not possible within the limits of the paper to deal with them all.

Construction of elliptical vaults.—With Fig. 2 are given the formulas and angles for the construction of a sewer with an elliptical vault, and the table of dimensions gives the radii, and the angles for seven sewer profiles.

In the appendix A the areas, perimeters and hydraulic radii are tabulated for various fillings expressed as percentage of the heights.

Method of constructing sewers with elliptical vaults.

Fig. 2.



Formulas of Construction.

$H_1 = B$

$H_2 = 0{\cdot}75\ B$

$R_0 = 0{\cdot}25\ B \quad \angle\ a_0 = 53^\circ{\cdot}08$ mins.

$R_1 = 1{\cdot}50\ B \quad \angle\ a_1 = 36^\circ{\cdot}52$ mins.

$\left.\begin{array}{l} R_2 = 1{\cdot}2\ B \\ R_3 = 0{\cdot}65\ B \\ R_4 = 0{\cdot}4\ B \end{array}\right\}$ When $H_2 = \frac{3}{4}$ B.

Table of Dimensions for Seven Sewer Classes.

SIZE.		HEIGHT. Lower	Upper	RADII. Invert.		Vault.		
B	H	H_1	H_2	R_0	R_1	R_2	R_3	R_4
ft. ins.	ft. ins.	ft. ins.	ft. ins.	ins.	ft. ins.	ft. ins.	ft. ins.	ft. ins.
2 0	3 6	2 0	1 6	6	3 0	2 $4\frac{3}{4}$	1 $3\frac{5}{8}$	$9\frac{5}{8}$
2 4	4 1	2 4	1 9	7	3 6	2 $9\frac{5}{8}$	1 $6\frac{3}{16}$	$11\frac{3}{16}$
2 8	4 8	2 8	2 0	8	4 0	3 $2\frac{3}{8}$	1 $8\frac{3}{4}$	1 $0\frac{3}{4}$
3 0	5 3	3 0	2 3	9	4 6	3 $7\frac{3}{16}$	1 $11\frac{3}{8}$	1 $2\frac{3}{8}$
3 4	5 10	3 4	2 6	10	5 0	4 0	2 2	1 4
3 8	6 5	3 8	2 9	11	5 6	4 $4\frac{3}{4}$	2 $4\frac{5}{8}$	1 $5\frac{5}{8}$
4 0	7 0	4 0	3 0	12	6 0	4 $9\frac{5}{8}$	2 $7\frac{3}{16}$	1 $7\frac{3}{16}$

General Formulas for Construction of Elliptical Vaults.

$R_2 = 2{\cdot}80\ H_2 - 0{\cdot}90\ B \quad \angle\ a_2 = 18^\circ{\cdot}26$ mins.

$R_3 = R_4 + (H_2 - 0{\cdot}5\ B) \quad \angle\ a_3 = 26^\circ{\cdot}34$ mins.

$R_4 = 0{\cdot}70\ B - 0{\cdot}4\ H_2 \quad \angle\ a_4 = 45^\circ{\cdot}0$ mins.

Calculations for the capacity of sewers.—There are a great number of formulas for calculating the capacity of a sewer, but only one will be given :—

$$S = c \frac{V^{1\cdot8}}{R^{1\cdot25}}$$

Where S = the grade per thousand.
c = coefficient of roughness for the sides of the sewer.
= 0·00013 for brick or masonry sewers.
= 0·000105 for pipe sewers.
V = the velocity in feet per second.
R = the hydraulic radius in feet.

This formula has been equated by Mr. Lindley from the experiments of Darcy-Bazin, and has been used by him in his extensive practice in designing sewers. It is plotted as a logarithmic diagram (Plate I.) on which the grade per thousand is given vertically; the velocity in feet per second horizontally, and the hydraulic radius in feet diagonally. By the aid of the diagram and the appended table of areas, &c., it is possible to determine any grades, velocities, hydraulic radii or quantities that may be necessary.

The seven sewer profiles and the pipe sewers have been likewise plotted as logarithmic diagrams (Plates 3—9) in order to facilitate calculations of capacity, &c.

These diagrams are to be read as follows :—

Scaling vertically is given the grade per thousand, horizontally the quantity in cubic feet per second, and diagonally the fillings of the profiles expressed as a percentage of the height. For instance, taking a sewer, 2 feet by 3 feet 6 inches, and assuming a grade of 5 per 1,000 or 1 to 200 running at 20 per cent. full, the quantity of water carried is 2·4 cubic feet per second. In this manner either the quantity of water, the size of a sewer, or the grade can easily be determined.

In calculating the capacity of pipe sewers it is advisable to consider the same as flowing half full, in order to allow the upper half of the sewer to serve for free circulation of air.

DRAINAGE AREA.

Delineation.—The first consideration in the design of a system of sewers is the area which it is intended to drain. Therefore,

in a large sewerage system it will be necessary to take an ordnance survey map of a suitable scale, fully contoured. By means of the contours the watershed lines can be traced out and the main drainage area determined.

In the case of an undefined or very extensive watershed a personal examination of the whole area should be made to delineate the drainage basin. The secondary watersheds and their secondary valleys within the main basin can be mapped out in the same general manner. After the main lines have been laid down, each individual sewer must have its individual drainage area determined. Within a town this can be simply done by means of assigning systematically the areas of the blocks of buildings to each particular sewer in accordance with the direction of flow. Care must be taken that only such areas are included on the down-hill side of sharply sloping ground as can be efficiently drained to the sewers by means of the house drains, the grades of which should not as a rule exceed 1 to 50 (Fig. 3).

An outlying area may be treated more broadly, but the ground levels must be kept in view. All these areas can be calculated either by means of a planimeter or in the cases of regular outlines by simple mathematics.

Preliminary levels.—If no town plans giving the complete configuration of the ground exist, it will be absolutely necessary to take preliminary levels over the whole of the main drainage area and to plot the contours resulting therefrom. Within the built-on areas, levels should be taken at all street or road crossings, at points of variation of grade and of level between the streets and the natural ground, as well as such high and low points, streams, brooks, underground conduits, old sewers, &c., as are likely to be determining factors in the ultimate design.

The outside unbuilt-on areas can be treated on more general lines, and only such levels need be taken as are required to determine the general configuration of the surface.

Benchmarks.—While taking these levels, the future should always be kept in view and accurate benchmarks left which will afterwards be of service in the actual carrying out of the scheme. The chiselled broad arrow of the Government must be considered as unsatisfactory and antiquated.

The best form of such benchmarks is a cast iron fang plug about 9 inches long, grouted or lead caulked into the wall

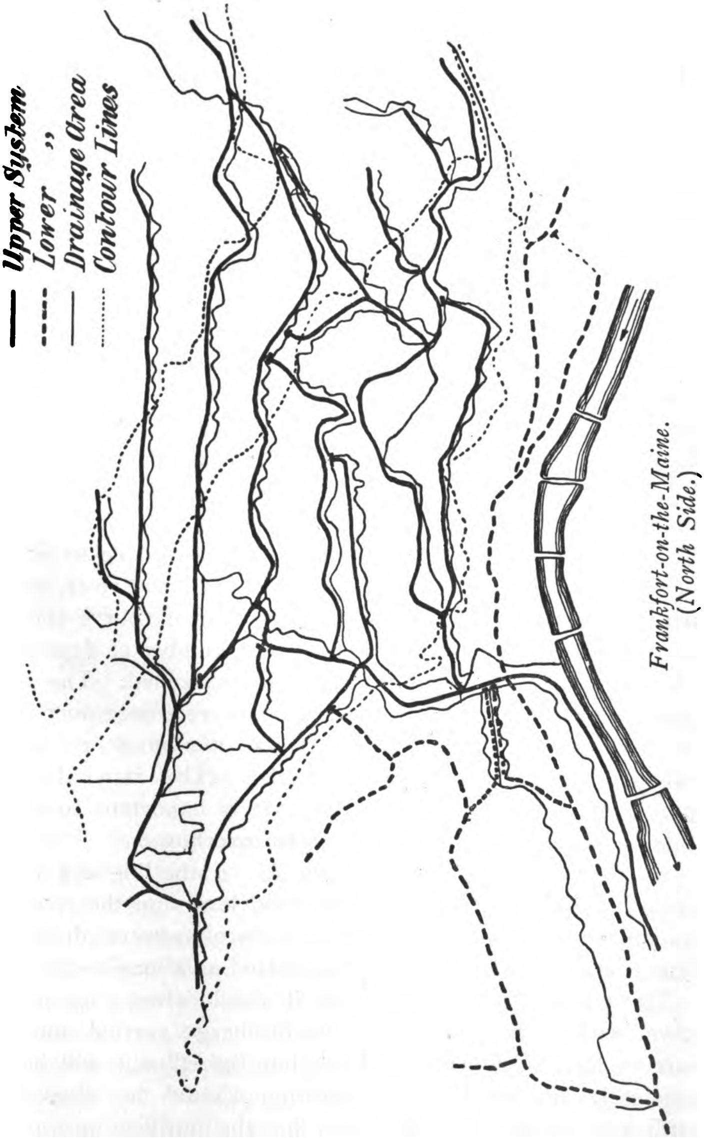


Fig. 3.—Sketch Plan showing the Principles of Interception, Sub-division in Upland and Lowland Systems, and Delineation of Drainage Areas.

of a permanent structure or building. This plug should have a round headed knob which will protrude about 1½ inches from the face of the wall, and which is so designed that the levelling staff may be conveniently and vertically placed on it. On the face of this knob a number can be cast or provision made for the later insertion of the level itself. An exact register describing the position and recording the level of each benchmark should be kept.

The chief requirement in choosing the position for such a benchmark is that it may be visible from as many sight points as possible, in order that it may have a maximum utility.

OUTFALL.

The position of the outfall for the sewerage system will be the next consideration. This will be determined to a great extent by the locality itself, whether the district will have to be drained to a river, to the sea, to a lake or to a small stream where the total quantity of the sewage may form a considerable percentage of its ordinary flow.

Outfall to a River.—In this case it is advisable to obtain the daily records of the various water levels of the river, extending over a long period of years. A time intensity curve should then be plotted, which will show the average number of days on which the various water levels occur or are exceeded. The rain-falls may be plotted on the same diagram for reference purposes, and it may be here pointed out that the maximum rains seldom coincide with the maximum floods. The rain always falls previous to the rise of the river. It is important to remember this in designing the rain and storm overflows.

Further, thorough information as to the highest floods on record must be obtained, as the flood levels on the river will be an important item in fixing the levels of sewers draining low lying districts. These should be plotted as a longitudinal section.

The position for the outlet itself should always be in the concave bend of the river, and the discharge carried out to the stream line, in order to ensure that the effluent will be diluted efficiently and quickly. A position should be chosen where sufficient acreage can be found for the purification works that may be necessary. Attention should be paid to the direction of the prevailing winds to avoid a possible nuisance arising from

these works, and due consideration must also be paid to all towns that may be situated downstream.

Outfall to an Estuary.—Many of the previous remarks apply to this case, but the problem is far more difficult, as hydrological and hydrographical examinations will have to be made on the intensity and variations of flow, and the scouring action of the tides.

Outfall to the Sea.—An outlet to the sea will require a very careful study, not only of the tides, but also of the tidal currents; and as sewage has a lighter specific gravity than the sea water, the action of the wind producing surface currents must always be taken into account. If such points as these are neglected, foreshore troubles, such as the spoiling of a beach, or the contamination of shell fish, &c., are likely to occur. These factors will decide the position and the length of the outfall sewer.

Outfall to Lakes.—The outlet in lakes should be laid far out from the shore and great care taken in the purification of the sewage.

Outfall to small Streams.—In the case of small streams, brooks, &c., the solution will depend almost entirely on the production of a satisfactory effluent and the efficient design of the purification works.

DETERMINATION OF MAIN LINES OF SEWERS.

The intercepting principle can be applied to the combined or the separate system. It may be more expensive in initial capital outlay, but it will be cheaper in working and maintenance than the radial system, for it requires long and large sewers at a greater depth, in contra-distinction to the short and small sewers with pumping stations.

The first maxim in the design of main and secondary sewers is that there must be no catchpits or sumps where decomposing sludge may accumulate. All grades must be evenly distributed, self-cleansing velocities chosen, and efficient flushing and ventilation provided.

Sub-division into upland and lowland systems.—In laying out the main lines of a sewerage system on the intercepting principle (Fig. 3) the general ground levels of the whole area and the advisability of dividing up the area into one, two or more systems of drainage must be carefully considered.

The lowland systems are those which carry the sewage to the outfall works at such a level that the sewage has to be lifted for purification and effluent purposes, or which are subject to the floods of a river.

The upland systems are those which gravitate sewage to the outfall works without its requiring to be pumped, or which are situated above the flood level.

A sub-division into two such main systems will have the advantage of decreasing the sizes of the main intercepting sewers; of reducing the cost of pumping; of preventing the high-lying districts from flooding the low-lying, and finally, of simplifying the treatment of storm water.

Main intercepting sewers.—In designing these main intercepting lines it will be of little avail to think only of the immediate present requirements. Such sewers must be laid out on broad principles for the far future, in other words, the lines of the sewers should be fixed even in undeveloped districts, or through areas not yet built on. Care should be taken that selfish interests of private individuals do not thwart the efficiency of a system. It should be remembered that the laws of Nature have no respect for county, district council or private boundaries. The author greets with pleasure the proposed legislation on town planning, but it must be remembered that in laying out new streets it is the hygienic requirements which are the primary governing factors, artistic considerations being but secondary.

It may be laid down as a rule in the intercepting system that there should be no dead ends to any sewers in a complete network, and that every sewer should receive its flushing from the sewer lying at a higher level. Dead ends will occasionally occur owing to the configuration of the locality, and in this case, special flushing reservoirs will have to be provided. These dead ends, however, will be few and far between, while they cannot be so easily avoided in the "radial" system.

The next point will be the complete study of the low points of the district, river crossings, brooks, old conduits, existing sewers, &c. These will influence the grade and the depth. It will be found useful to survey the depths of cellars and sub-basements of existing structures and buildings, in order that a thorough system of house drainage may be carried out afterwards without detriment to the house properties.

After considering these general principles it must be remembered that the grade of a sewer carrying an appreciable quantity of water should be determined either from the dry-weather flow or the wet-weather flow. These two levels will govern the efficiency of the sewer for the house drainage; the former giving the maximum grade for such drains, the latter the possible flood level. In low-lying districts it will be wiser to fix the wet-weather levels, equivalent to the soffit of profile, for, though it may be impossible to lay the sewer deep, it may be possible to lay it deep enough to prevent flooding of cellars and basements.

The levels of the dry-weather flow being fixed, the invert levels are determined, the water depths being calculated by means of the quantities obtained from the area plan, already described, and by the velocities resulting from the chosen grades. The invert will step up in accordance with the required depths, or in other words the mean invert grade will be a slightly increased one to that of the dry-weather flow.

In choosing the grades the economic size of a sewer must be taken into account, *i.e.*, not only the present cost of construction, but also the serviceable value from the hygienic point of view to obtain a maximum efficiency at a minimum cost. Therefore, it will not do to choose too flat a grade with a poor velocity, destroying the self-cleansing properties (which require at least a velocity of 2 to 2½ feet per second), thereby entailing great cost of construction, when a smaller sewer with a steeper grade would prove more economical.

The average depth of the sewers for obtaining efficient drainage will be found to vary between 13 feet and 15 feet.

Flushing Sewers.—High or ridge lines must be reserved for the flushing sewers. These sewers should be kept as shallow as is consistent with the house drainage requirements, in order to obtain good grades for the side branches. A flat grade may be chosen for such sewers, as this will give them greater flushing capacity.

Separate System.—In designing sewers for a separate system some different considerations will apply. In this case there are two networks to be designed. If both the dirty water and the rain water systems be built at the same time, it will be more economical to place them in the same trench. As, however, they

will lie at different levels, the dirty water sewer being the deeper one, care must be taken that a good foundation exists for the rain water sewers, otherwise there may be serious side slips or breakage. The rain water sewers should be inter-communicating at their upper ends for flushing purposes.

In the separate system most of the sewers will be pipe sewers, and only in the case of a very large district will sewers of a larger section have to be resorted to. It may, however, be possible in a small town or village, that the dirty water system will suffice, and that the rain water can be carried off by actual surface drains to water courses, &c., without causing any serious inconvenience.

DETERMINATION OF SECONDARY SEWERS.

The lines for the secondary main sewers should be so determined that the sewers do not concentrate great quantities of water at one and the same point, but that they distribute the flow as evenly as possible over the whole length. The evils of two or more secondary sewers discharging at one point in a main sewer will be felt at times of heavy rains, as the carrying capacity of the main sewer will be locally overtaxed, and its efficiency reduced.

The method to be followed in designing the secondary side or branch sewers will be that of careful distribution of available grade between two main intercepting sewers. Each branch sewer at its upper end, must be in communication with the higher lying sewer, so that by a systematic arrangement of penstocks and flap valves, the sewage can always be diverted down any one side sewer to flush the latter.

Therefore, in proceeding to calculate the grades of the network of branch sewers, all the street lengths between the intercepting sewers must be carefully measured. The longest line with the least difference of levels should be selected. In addition to this grade, allowance must be made for differences of level between the inverts of the flushing sewers and branch sewers to be flushed, for it will be necessary to place the upper inverts of the outgoing or flushed sewers higher than those of the through-going or flushing sewers, in order to keep a fair waterway on the through-going sewers. These differences of level should be about 4 inches, and never more than 8 inches, unless under exceptional circumstances.

The addition of these differences of levels divided into the lengths measured, will give the ruling grade along the most disadvantageous line, and all the other dependent grades will naturally be steeper.

RAIN OVERFLOWS.

The number of rain overflows will depend largely on the area to be drained, and on the actual natural resources that exist for carrying off the rain water. They are sub-divided into two classes, viz., rain overflows and emergency or storm outlets.

The rain overflows are those which come ordinarily into action, whereas the emergency or storm outlets are only occasionally used in times of excessive storms to prevent floods. It is well to repeat here, when using a river as the outfall for such overflows, that the highest floods in the river will not, as a rule, coincide with the heaviest rains, for the rains are the precursors of floods. The diagram of river levels and rainfalls already referred to will be of great service in fixing the invert levels of the storm overflows at their upper and lower ends.

The points, at which rain overflows will take their discharge, will be at junctions of one or more sewers in order that the main intercepting sewer may not be overcharged, or its size be prohibitively large and expensive.

Ridge or high level lines should be chosen for the trace of such outlets as far as is feasible, so that sufficient covering between the street and the masonry vault may be obtained when crossing over the sewers.

MATERIALS FOR SEWER CONSTRUCTION.

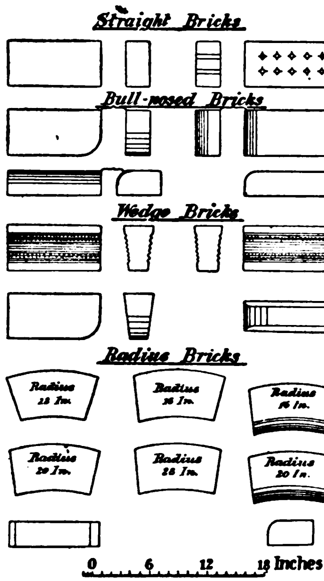
All materials used in the construction of sewers should be of the very best quality.

Bricks.—Bricks should be used for the construction of masonry sewers and their special constructions, such as junctions, manholes, &c., and also used for similar structures on pipe sewers. Various types of sewer bricks are shown in Fig. 4. They must above all be free from lime, even, close grained, thoroughly burnt, free from all blisters, cracks, extraneous matter, &c., and give a clear ringing note when struck with a hammer; they should be smooth faced, more particularly for inside work; the edges, corners and sides should be carefully protected during transport against breakage, chipping and damage. No

bricks, which are in the least way imperfect, having corners knocked off or cracks, should be used for internal exposed work. Such bricks should be sorted out and used only in the second rings of masonry. The bricks should not absorb water to more than 12 per cent. of their weight.

All bricks to be used below ground should be thoroughly soaked up to their absorption capacity. This is essential for good masonry in order to prevent the moisture being drawn out from the mortar before it has had time to set.

Fig. 4.—Sewer Bricks.



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Stoneware.—Stoneware should be used as much as possible for all pipes, invert blocks, ventilation and junction pieces. Typical forms of such pieces are shown in Figs. 5 and 6. The material should be of first class quality, and evenly glazed on all exposed surfaces. This glazing should be a salt one, and should be formed during the burning. No application of artificial glazing material, either previous to or after the burning, should be allowed.

Stoneware inverts are preferable to brick inverts, as they are more durable and expose the fewest joints to the attacks of the

raw sewage at the most vulnerable part of a sewer. Invert and junction blocks must be made to brick dimensions. Stoneware junction blocks should be used for brick sewers and branch pipes for pipe sewers. On no account must drainage connections to brick or pipe sewers be permitted to be made by the simple insertion of the end of a pipe into the wall of the sewer.

Stoneware Ventilation, Invert and Junction Blocks.

Fig. 5.

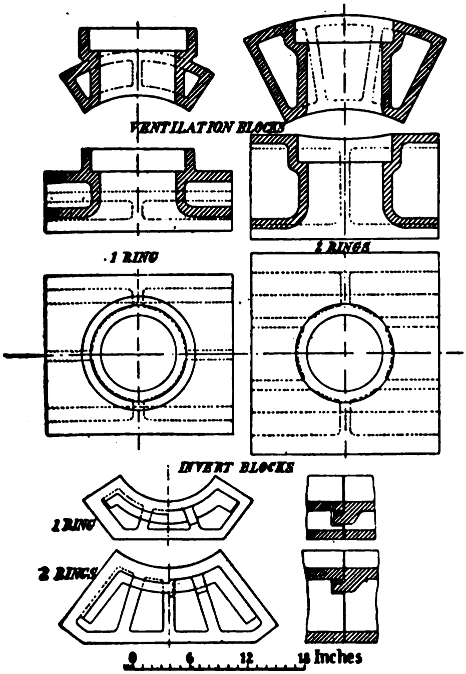
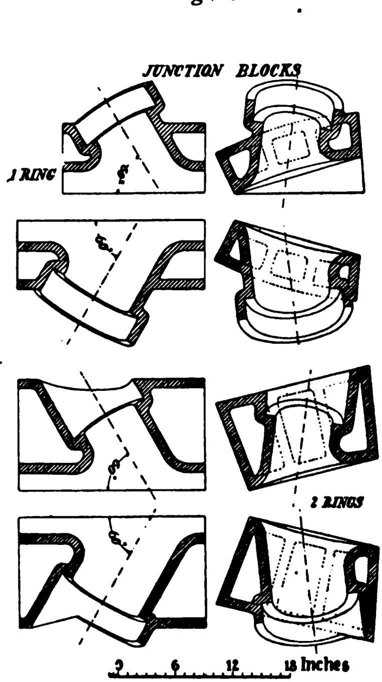


Fig. 6.



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In the case of pipes the interiors of the sockets and the spigot ends should be rilled for at least the full depth of the socket. They should be truly circular, quite smooth, straight and free from all blisters, protuberances, &c. The junction pieces for the house and gully connections should be made with an inflow angle of 60°, this angle of flow being the least disturbing.

Cement.—The cement should be slow setting and pass the British Standard or prescribed Specifications and Tests. The mortar usually used will be three parts of sharp sand and one

part of cement, and the pointing mortar either one to one or neat cement, in accordance with the requirements.

Concrete.—Concrete should only be used for foundation and outside work. It will be mixed to the appropriate strength to meet the exigencies of the case. It will here be noticed that concrete (reinforced and otherwise) has not been mentioned as suitable material for sewer work. Although concrete sewers are being built all over the world, more especially on account of their attractive cheapness, it is the author's conviction, based on experience, that unprotected concrete is not a suitable material to be brought into contact with raw sewage. It may, however, be used in the case of very large profiles, such as brook vaultings or rain overflows, where the concrete will be exposed only from time to time to very dilute sewage.

Sandstone.—For special purposes, such as overflow saddles, ironwork seatings and fixings, special ventilation, invert and junction blocks for manholes, &c., the use of sandstone or some hard stone, granite, &c., although expensive, is to be recommended. This sandstone should be free from all lime, and of a fine quartz non-absorbent nature. In the various illustrations of special work, the uses to which sandstone has been put, are clearly shown (viz., by the hatching). All the round edging should be made to suit the radius of the bull-nosed bricks.

Iron Pipes.—Iron pipes will be used under special circumstances, such as river crossings, loose ground, &c. The thickness of such pipes can be designed especially to meet the requirements, for, with the exception of pumping mains, it will be a rare occurrence that the pipes have to work under great pressures.

General Ironwork.—All sewer ironwork, more especially that which will be built into the sewers themselves, should be of strong construction. It should be thoroughly coated with Dr. Angus Smith's, or some similar solution, and should be regularly inspected and coated as required. These precautions are necessary, as the ironwork is exposed to varying degrees of moisture and temperature. The design should be as simple as possible, as the ironwork will have to resist the action of the sewage and withstand the rough handling of the sewer men. Figs. 22 to 37 show a series of ironwork constructions embodying the above principles.

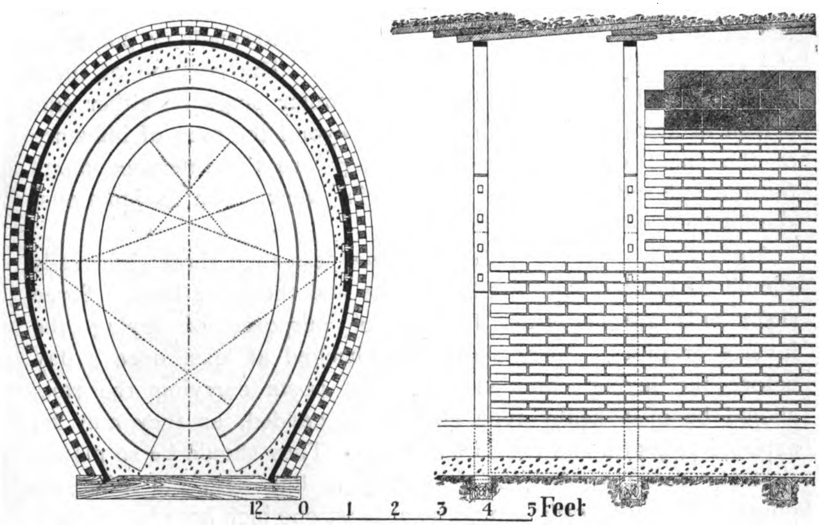
SEWER CONSTRUCTION.

Sewer Trenches.—It is not necessary to describe the timbering required for sewer trenches, after the very practical paper on this subject by Mr. C. W. Pettit. (See Vol. XVII. of Transactions, pp. 279 *seq.*).

It may be well to remark that the trenches should be kept short and in strict accordance with the progress of the work. The trench work should be so arranged that a length at full depth equal to a day's masonry work or pipe laying should always be laid bare and a similar length always completed. This is necessary to minimise the dislocation of traffic due to the narrow limits within which such work has usually to be executed.

Sewer Tunnelling.—In narrow streets or where great traffic exists, it may be necessary to tunnel. Fig. 7 shows the method

Fig. 7.—Sewer Tunnelling.



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adopted in Frankfort-on-Maine, Mannheim, Prague, Warsaw, &c. Its chief feature is the excavation of the soil to the profile of the sewer. Pipe sewers should never be laid in tunnels, or only laid in such short lengths that the tunnel excavation can be thoroughly filled in without detriment to the pipe line.

Levelling and Setting out.—All sewer levelling must be

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than $\frac{1}{4}$ inch and not more than $\frac{3}{8}$ inch. At the back of the brickwork it should not exceed $\frac{5}{8}$ to $\frac{3}{4}$ inch. These limitations will determine the brick sub-divisions. It must be remembered that the profile must be made up of whole bricks, and that the standard dimensions of bricks adopted are the measure to which all constructions must be worked. All cutting of bricks should be strenuously avoided, as it only results in defective and expensive work. This will require the setting out of all sewer brickwork to a large scale and calculating the sub-divisions. As a guidance for such work, it may be useful to summarise the possible combinations whereby wide joints may be avoided, namely, the simple straight; the simple wedge; one straight with one wedge; two straights; two wedges; one wedge, one straight, one wedge; and one straight, one wedge, one straight; it is only a matter of patience to adjust the divisions. These divisions should be calculated for all rings.

All curves should be as wide as possible, and never less than ten times the breadth of the sewer. The inverts of the small sized sewers are liable to become special in sharp curves unless precautions are taken to set out the curves to radii which permit the standard stoneware invert blocks to be used without obtaining wide splayed joints.

Sewer Building.—The brickwork division should be notched on the invert templates and lined with pencil on the vault drums. The earth backing should be filled in simultaneously with the progress of the brickwork. The drums should be withdrawn after the cement has set, and the whole profile at once pointed. The mortar should be thrown on the bricks so that the joints are full and the bricks well bedded and pressed home to the gauge lines. The joints should run in true lines. All defective work such as uneven jointing, cracked or chipped bricks, should be cut out. The sewer above all should be water tight and impervious.

Pipe Sewers.—Pipe sewers should not be larger than 18 inches in diameter; *firstly*, on account of the difficulty of manufacturing these large diameters; *secondly*, because of their insufficient strength to resist earth pressures, and *thirdly*, because it will be cheaper and more efficient to build a brick sewer of an egg shape profile which is capable of being inspected.

Stoneware pipe sewers should, as a rule, be laid in open

trenches and not at greater depths than 15 to 16 feet, or the earth pressures may cause a collapse. All pipe sewers should be laid in straight lines from manhole to manhole to provide for efficient inspection and flushing. It may be advisable in the case of a large pipe sewer discharging great quantities of sewage into a brick sewer to build a junction with a short piece of brick sewer in curve, in order to facilitate the flow of the sewage.

Sewer Pipe Jointing.—The methods of jointing pipe sewers (not taking into account the legion of patent sockets and spigots) are, *firstly*, gasket and well kneaded stiff clay; *secondly*, gasket and cement; *thirdly*, tarred gasket and asphalt composition, which was used first by Mr. W. H. Lindley on the sewerage works of the City of Elberfeld, nearly twenty years ago.

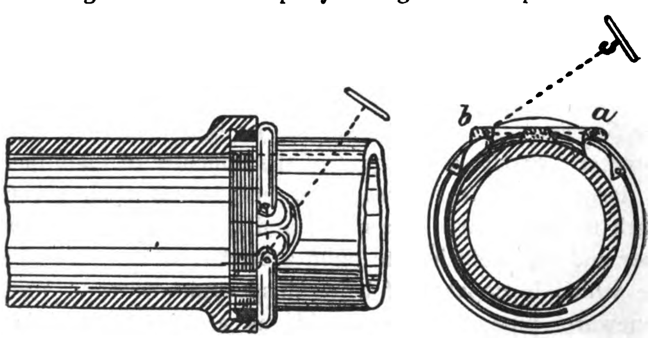
It is well to insist again that pipes should be laid so that the *body of the pipe*, not the *socket*, rests on the soil. Defective pipe laying is very expensive.

The *first method* has practically died out owing to the fact that the clay joint, although ideal from the point of view of flexibility, suffers from the attacks of worms and roots of trees.

The *second method* has the great objection and disadvantage of making an absolutely rigid joint, which is often made still worse by laying the pipe on a 6 inch layer of concrete, or even embedding it entirely in concrete.

The *third method*, tarred gasket and asphalt, has undoubtedly all the properties required for a sewer pipe line, viz., easy construction, water tightness, flexibility, imperviousness and cheapness. Fig. 8 shows the method of procedure in making an asphalt joint.

Fig. 8.—Sewer Pipe Jointing with Asphalt.



After a pipe is truly laid and two strands of well-tarred gasket have been caulked home, a thick roll of canvas or a rubber or cork ring smeared with clay, leaving a small opening at the top for pouring in the asphalt, is pressed hard up against the annular socket space so as to prevent any outside leakage. The asphalt is then poured in similarly to the pouring in of a lead joint. This method is simple. Should a faulty joint be poured, it is easily found out on inspection of the outside after removal of the ring; or should any of the asphalt have leaked to the interior of the pipe, the fumes rising from the interior will at once allow the fact to be detected.

It has the further advantage that a pipe can be withdrawn with the greatest ease by melting out the asphalt with a brazier's lamp.

Connections to Sewers.—In laying a sewer, ample provision for house and other connections should be made. This will mean inspection of all the houses along the route of sewer, and the determination of the most suitable course for the house drains. The junction blocks can then be inserted during construction. In the case of unbuilt-on areas, the probable arrangement of the building plots should considered and provided for. These precautions will prevent tampering with good work, as the insertion of junction blocks is not easy, and unless executed with the greatest care, is very likely to be detrimental to the efficiency of a sewer.

The junction blocks for street gulleys and the house drains should be placed in the side of the sewers, so that the inverts lie just below the dry weather flow level, in order to prevent disturbance of flow as much as possible.

SPECIAL CONSTRUCTIONS AND THEIR ACCESSORIES.

Brickwork.—It will be well here to repeat the requirements of the brickwork.

All designs for special construction should be carefully worked to the standard brick dimensions to avoid cutting and waste. All special stoneware, sandstone or concrete blocks should be made to coincide with multiples of these dimensions. The joints should be straight in line and should not exceed $\frac{3}{8}$ inch in width. All sharp edges and awkward corners should be avoided; bull-nose bricks should be freely used in all oversailing and edge work. All

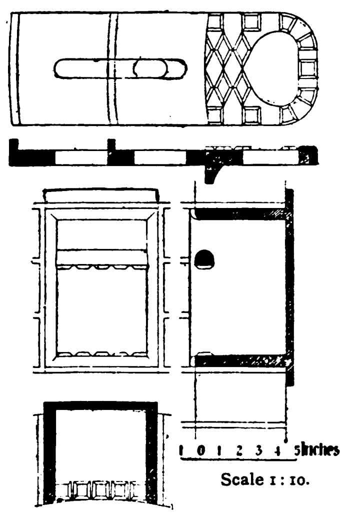
walls, facework, &c., should be arched instead of straight, in order to economise in brickwork and to distribute the earth pressures more evenly. All projections, &c., in the sewer profile, must be strenuously avoided, as they are liable to impede the flow or to allow solid matters to collect. All brickwork should be constructed so that it may be easily washed down and kept clean; for it must be remembered that sewage, unless carried off without delay, will undergo immediate putrefaction. Lastly, the brickwork must be simple, first-class and attractive, with plenty of accommodation so that the workmen responsible for the maintenance have not only pride in their work but also pleasure in keeping the sewers in good condition.

Manholes.—Manholes should be placed at intervals of 120 to 150 yards on brick sewers, and 100 to 120 yards on pipe sewers. Types of manholes on brick and pipe sewers are given in Figs. 9 and 10, and flushing manholes in Figs. 12 and 13 (Plate 10), showing the principles of flushing sewers with the arrangement of pen-stocks and flap valves. The ironwork details are given in Figs. 25 to 28 (Plate 15).

Fig. 24.—Stepirons, Plain and Countersunk.

Plain Stepirons for one or two rings of Brickwork.

Countersunk Stepirons.



Attention is drawn to the sandstone junctions and inverts, their radii and differences of level, to the arched walls, as well as to the circular form of the shaft or of the manholes themselves. The

circular form is the cheapest and should always be used where possible, and almost without exception on pipe sewers. One side should always be vertical to receive the stepirons (Fig. 24); all stepirons set on a slanting wall are dangerous. This side should be so chosen that the workman finds a good footing when he reaches the invert. Thus the oversailing of the brickwork should be on one side only, and gradually run off flush with the vertical side.

All flap valves of pipe sewers should be ventilated to the manhole, so that there is free circulation of air, and all penstocks in pipe sewers should be provided with an overflow 3 to 4 feet above the invert. In a brick sewer the half profile hand penstock will form its own overflow. The level of the overflow will determine the available flushing head.

Manholes on outlet sewers with flap valve and penstock are shown in Figs. 14 and 15, Plate 11. Two such manholes will be always necessary on outlet sewers exposed to river floods and the like. The flap valve, which does not afford sufficient security for water tightness, has the function of a preliminary protection against flooding until the penstock can be lowered.

Attention is here drawn to the careful stone setting of the ironwork, and the countersunk stepirons to avoid projections in the sewer profile which might be liable to retain putrefying solids, and to the stepped seating to avoid the accumulation of sludge liable to prevent the accurate closing of the gates. Details of the construction of the penstock are shown in Figs. 32 and 33, Plate 16. The counterbalance arrangement is to facilitate the operation of raising and lowering.

Covers for manholes should always be circular; oval, square, or oblong covers may cause accidents by being able to pass through the cover opening if carelessly dropped while being lifted. Fig. 34, Plate 17, shows a circular cover fitted with a dirt box and designed on the telescopic principle, so that, should the roadway level be lowered or be raised, true adjustment to the final street level can be made without tampering with the brickwork.

Side Entrances.—Side entrances, instead of manholes, should always be constructed where heavy traffic exists. *Firstly*, to prevent dislocation of traffic when the sewer must be entered for flushing or other purposes; and *secondly*, to reduce the number of covers in the roadway.

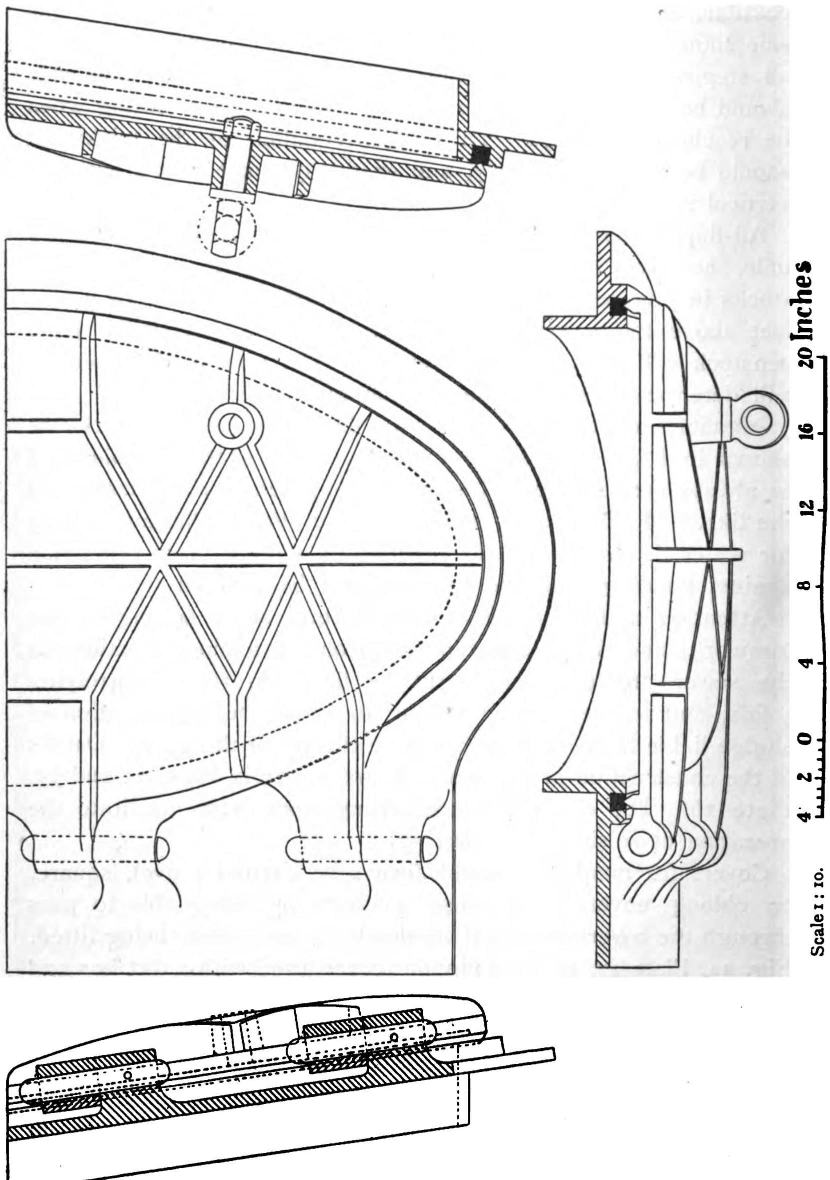


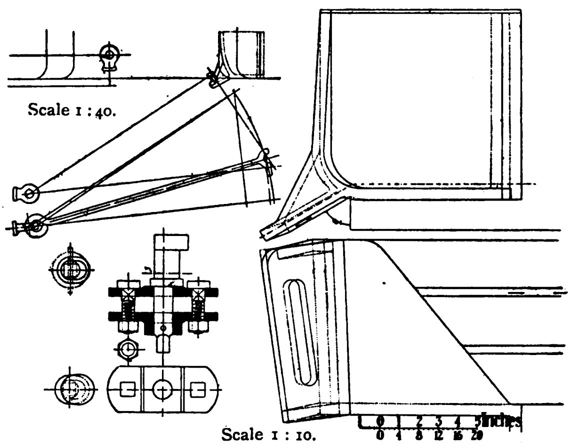
Fig. 30.—Flushing Gate for Brick Sewers.

Details of these works are given in Fig. 11, Plate 10, Fig. 16, Plate 12, the latter shows the arrangement for flushing gates, the ironwork of which is given in Figs. 30 and 31.

Attention is here drawn to the methods adopted to avoid all dead corners likely to accumulate filth in the sewers. The side entrance itself is graded back to the sewer. Care should be taken in designing such entrances that there is plenty of cover above the vault to allow any pipes, cables, &c., to pass over it.

The flushing gate is set with a slope of about 1 to 10 against the direction of flow. The flushing bar, when the gate is closed, is held in position at its knuckle end by an eccentric clutch (Fig. 31) fastened to the anchor plate on the off side of the

Fig. 31.—Anchor Plate and Eccentric for Flushing Gate.



entrance chamber. This eccentric is so mounted, that the workman, holding the bar in one hand, turns and frees the knuckle from the eccentric by means of a key, and in doing so, retreats up the side entrance. The gate swings across, and prevents the rush of sewage up the entrance.

Side entrances with flushing gates should be placed in accordance with grade of the sewer, and at such points where it is required to flush branch sewers. On sewers without any side branches or having branches only at long intervals, flushing gates should be provided at about 200 to 300 yards. An appropriate covering for side entrances is shown in Fig. 35, Plate 18. It is provided with a safety grid, which is self locking when the

upper cover is open, and which is strong enough to carry ordinary foot traffic.

Junctions and similar works.—The construction of a junction is shown in Fig. 17, Plate 12. The junctions of one or more branch sewers with a main sewer must be designed so that the water level at the junction will remain fixed, and the inverts placed at a level in accordance with the calculated depth of the dry-weather flow. This will prevent back-wash from the main sewers up the side sewers, should the level of the latter be placed too low, and will prevent the undue backing-up of the sewage in the main sewer by a higher velocity of the inrushing water from a side sewer, should the level of its invert be placed too high.

It is always advisable to give the through-going sewer a little extra grade on the length of the junction, in order to compensate the differences of velocity that may occur, the larger quantity of sewage requiring a lesser velocity to maintain its self-cleansing properties than the smaller quantity flowing in the side sewers.

The brickwork of the trumpet vault should be divided up, commencing at the soffit, and run out along the spring of the vault, *i.e.*, the sub-division of the brickwork of the vault of the through-going sewer should be adhered to. The head wall should be built as a free wall, and not bonded to the vault, in order to prevent cracks, should a slight subsidence in the vault take place. Attention is drawn to the saddle between the sewers and to the ventilation at the highest point of the vault.

Junctions should be kept as short as possible to avoid unnecessary expense. This can be done as follows:—The head breadth of the junction (Fig. 17, Plate 12, section A.A.) is determined by the two rings of brickwork of the incoming sewers. The angle of the junction is given by the setting out, and should be sharp, not exceeding an angle of 60° to the throughgoing axis. This angle will determine the length of the natural junction. A length equal to about one-tenth of this total length may be cut off from the end without interfering with the angle of flow or causing difficulties in the brickwork construction. Overflow junctions with weirs for rain outlets are similar in construction, but in the reversed position. The weir should be kept as long as possible, and the depth of overflowing water should be limited to about one foot.

Other types of special junctions or "strangers' galleries"* are shown in Figs. 18, 19, and 20, Plates 13 and 14. These have been constructed at junction points of special interest in order that the sewers may be inspected with comfort and their working demonstrated. The ratepayers have thus an opportunity of appreciating in a practical manner where and how the money has been spent for their benefit.

Ventilation.—This is a vexed question, and a complete paper might be written upon it. The author, however, is firmly convinced that there is only one real logical and practical method of ventilating sewers, viz., by means of intakes at the street level and outlets by means of the soil and waste pipes of the house drains, and the rainwater down pipes. Of course, in exceptional localities, where sewers, for instance, pass through undeveloped areas, other methods, such as specially constructed ventilating shafts, may have to be resorted to. Ventilating sewers by means of the house drainage pipes means doing away with the intercepting trap. While condemning the intercepting trap as a serious impediment for good ventilation, and as an unnecessary obstruction to house drainage work, the author admits there are unfortunately many systems of sewers which are so defective that men have been killed by the effect of accumulations of sewer gas. Such systems therefore demand the use of some preventative invention of this kind to protect the house properties.

The author believes that in a system of sewers properly constructed, well maintained and embodying the principles set forth in this paper, no dangerous sewer gas can or will exist in the sewers, as the sewage will be carried off long before putrefaction has had time to set in. He believes, further, that a great part of the expense and trouble, which arise in the design and in the efficiency of purification works, is due to the defective systems of sewers themselves and the unsatisfactory state in which the sewage arrives at the outfall.

The system of through-ventilation demands good plumbing and conscientious house drainage work, with strict inspection and under strict regulations. Nothing should be allowed to prevent this being achieved in the construction of new sewerage works.

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*The Strangers' Gallery at Hanau was inspected by the members of the Institution on the occasion of the Summer Meeting in Germany, 1904. See Transactions, Vol. XIV., p. 230-232.

THE DESIGN OF A SEWER.

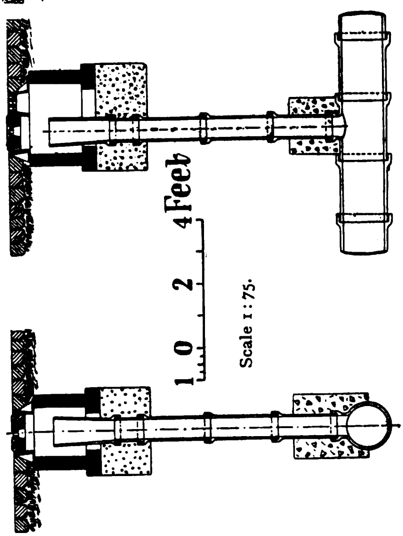


Fig. 21.—Sewer Ventilation Pipe Sewers.

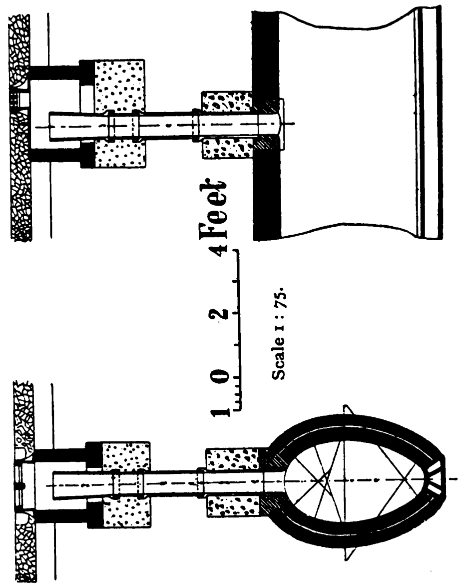


Fig. 22.—Sewer Ventilation Brick Sewers

The ventilation on brick and pipe sewers are shown in Figs. 21 and 22, and the appropriate iron work in Figs. 36 and 37, Plate 17. These vent pipes should be placed every 25 or 35 yards, and on all vaults of special construction (junctions, &c.), where air locks are likely to occur.

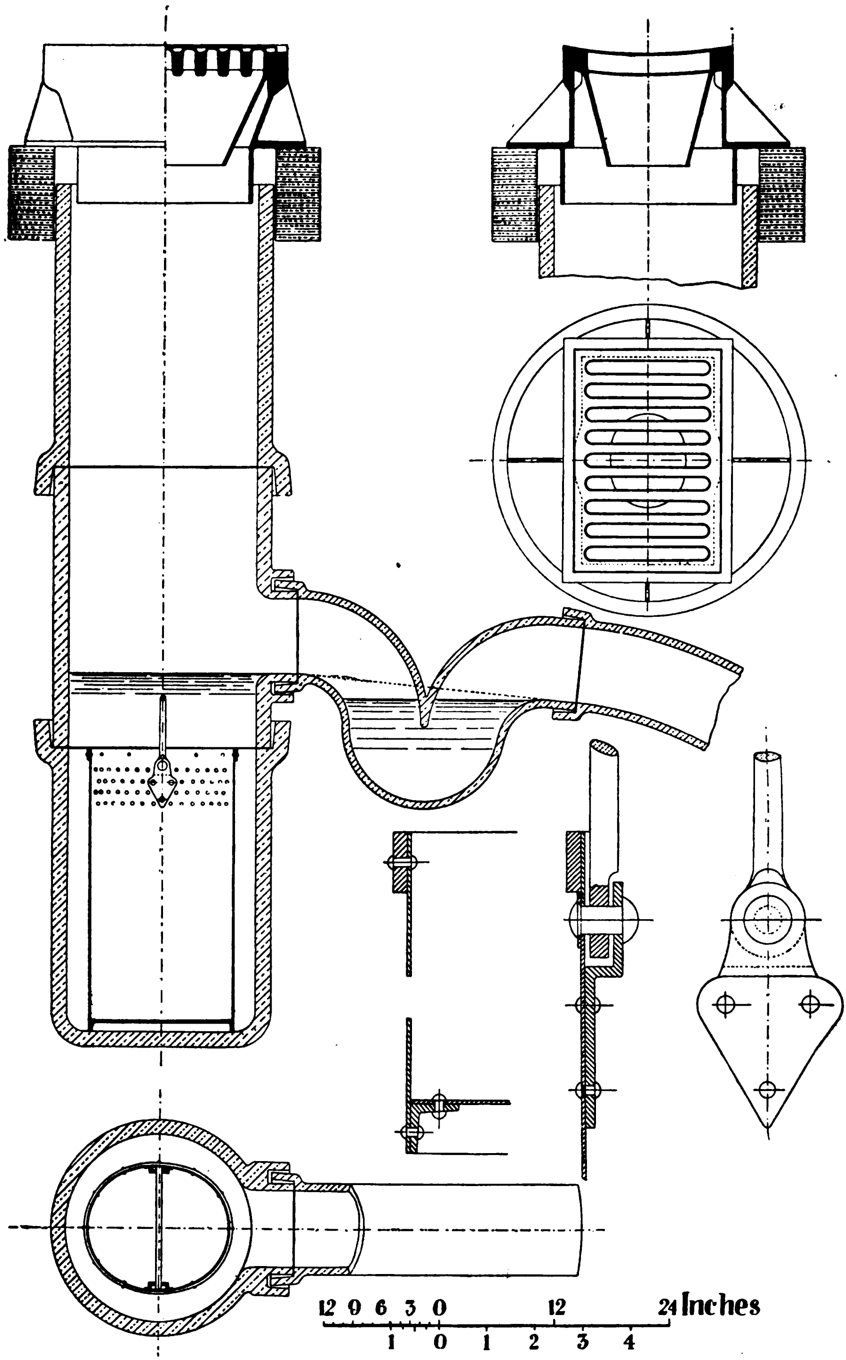
The construction shows the first pipe from the sewer concreted in to keep it straight and to provide a good seating for the rising vent pipes. The brick shaft at the street level should have a clean gravel filling in order that all water flowing in from the street may quickly percolate. The covers should be made removable, so that these shafts may be cleaned out from time to time. The vent pipes should be placed to one side of the grid, so that dirt or water cannot fall straight into the sewer from the street level. These grids will act as fresh air intakes to the sewers on the through-system of ventilation.

Gullies.—Street gullies should be designed to have their traps below the influence of frost, and should be constructed so that they are easily cleaned. The gratings and the capacity of the catch basins should be in accordance with the grade and nature of the street. A type of deep trap gulley used extensively on the Continent is shown in Fig. 23. It is provided with a dirt bucket. This has the advantage that the cleaning is simplified by the withdrawal of the bucket. This is usually performed by a small hand crane fitted to a special cart, with a tipping platform to receive the bucket, thus reducing the handling of the sludge from the gullies to a minimum. The trap of the gulley should be always laid in line with and under the gutter, to facilitate repairs without having to open up the roadway, and so disturb the traffic. The junction blocks of a pair of gullies (one on either side of the street) should be staggered and not directly opposed to each other, in order to prevent disturbance in the flow of sewage as much as possible. Gullies should be spaced in accordance with requirements, avoiding the possibilities of puddles collecting at street corners in case of stoppages. They will be usually about 25 to 30 yards apart.

FINAL SURVEY.

After the construction of a sewer is complete, a plan, a

Fig. 23.—Deep Trapped Gully.



Scale 1 : 20.

longitudinal section, and a complete record should be drawn and filed. These plans should give the true position of the sewer and its depth; all particulars as to the setting out of the axis curves and angles; the position and depth of all junction blocks provided for; the branch connections which may have been simultaneously carried out; all special constructions, manholes, ventilations, &c., as well as all water and gas pipes, cables, &c., that may have been met with, diverted or removed; the position of the street gullies and their connection to the sewers, and the geological strata passed through. These plans should always be kept up to date for reference purposes.

MAINTENANCE.

Maintenance should be carried out in accordance with a fixed programme. All sewers should be flushed at regular intervals, the gullies cleaned as required, the brickwork washed down, the ironwork greased and painted, and the ventilation shafts scraped out at least once a year. A well constructed system of sewers is not expensive in maintenance, for instance, taking the City of Frankfort-on-Maine, with a total number of inhabitants in 1902 of about 300,000, with a sewer network of 160 miles, the maintenance was carried out by a staff of 20 men at a total cost of about £2,075 per annum, or about £13 per mile of sewer per annum.

CONCLUSION.

In conclusion, let it be remembered that although sewers are the recipients of waste products of human consumption, there is no reason why they should be neglected or treated with disdain. A well-designed, well-constructed, and efficiently maintained system will always be a source of satisfaction, not only to the Engineer and the workmen, but also to the population which benefits by it.

The author is aware that he has by no means exhausted the subject of the paper, but he hopes that the information, as far as it goes, may be an acceptable addition to the many useful papers published in the Transactions of the Institution, and that it may form a suitable supplement to that practical paper read by Mr. G. H. Hughes, M.I.Mech.E., on the "Design of Water-

works."* He wishes once more to express his gratitude to Mr. W. H. Lindley for his kindness, and his thanks to his own draughtsman, Mr. W. S. Rapley, for the care he has taken in assisting him to prepare the drawings for the blocks.

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*See Vol. XV., Transactions of Junior Institution of Engineers.

APPENDIX A.

of Area lliptic

4ft. oin.	Si	× 5ft. 1o		r : 4ft. oin. × 7ft. oin. See Plate 9.		
Hydr. Radius feet.	Hei fee	ter	Hy Ra fe	in et.	Perimeter feet.	Hydr. Radius feet.
0·140	0·2	46	0·	48	1·855	0·241
0·226	0·4	57	0·	94	2·591	0·384
0·377	0·9	1	0·	94	4·200	0·646
0·500	1·3	0	0·	4	5·712	0·852
0·603	1·8	7	0·8	4	7·164	1·026
0·687	2·3	6	0·9	4	8·574	1·172
0·734	2·6	0	1·0	4	9·576	1·257
0·745	2·7	3	1·0	2	9·997	1·284
0·781	3·2	0	1·1	2	11·389	1·368
0·827	3·7	8	1·1	2	12·836	1·412
0·833	4·1	3	1·1	2	14·249	1·422
0·808	4·3	3	1·1	7	15·075	1·382
0·718	4·6	7	1·0	3	17·588	1·229

HALF FULL.

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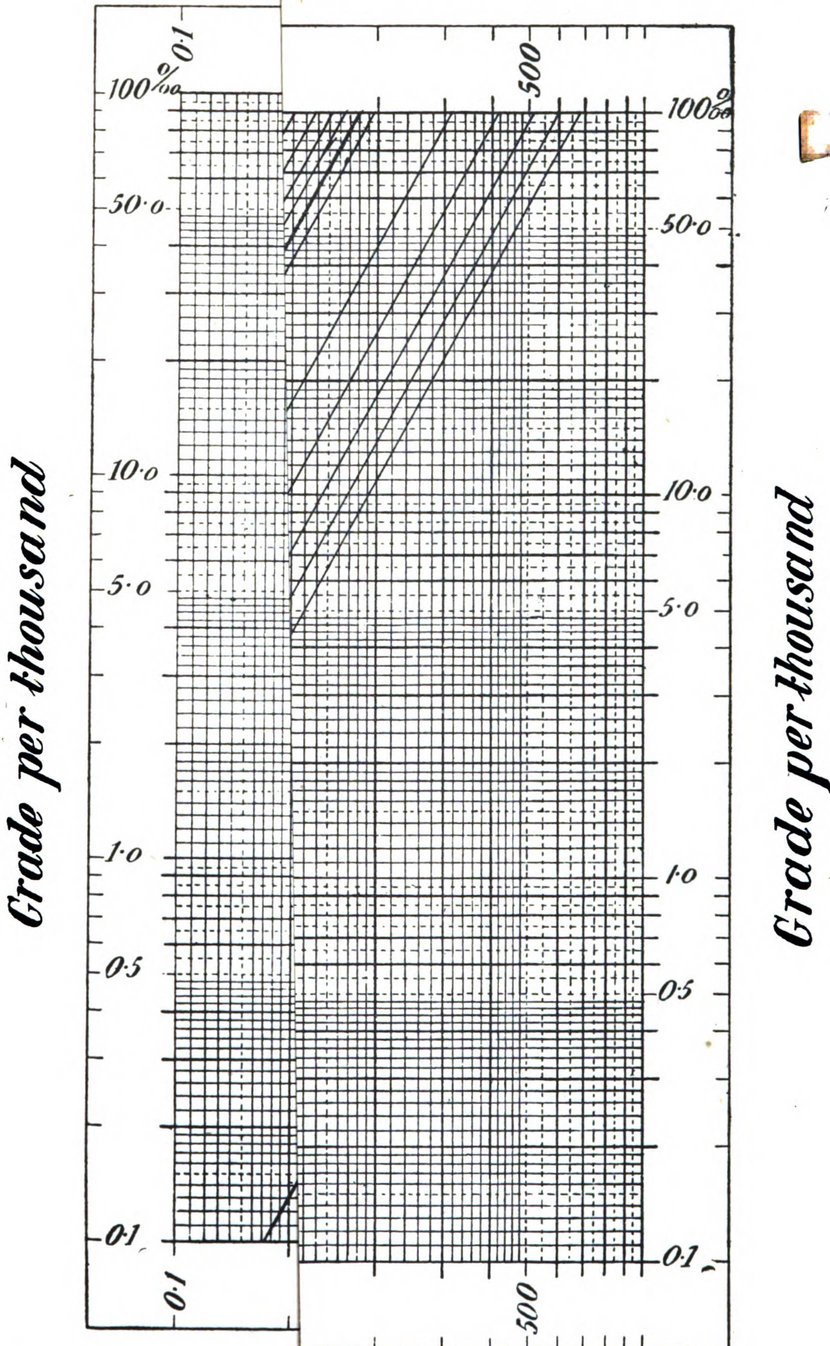
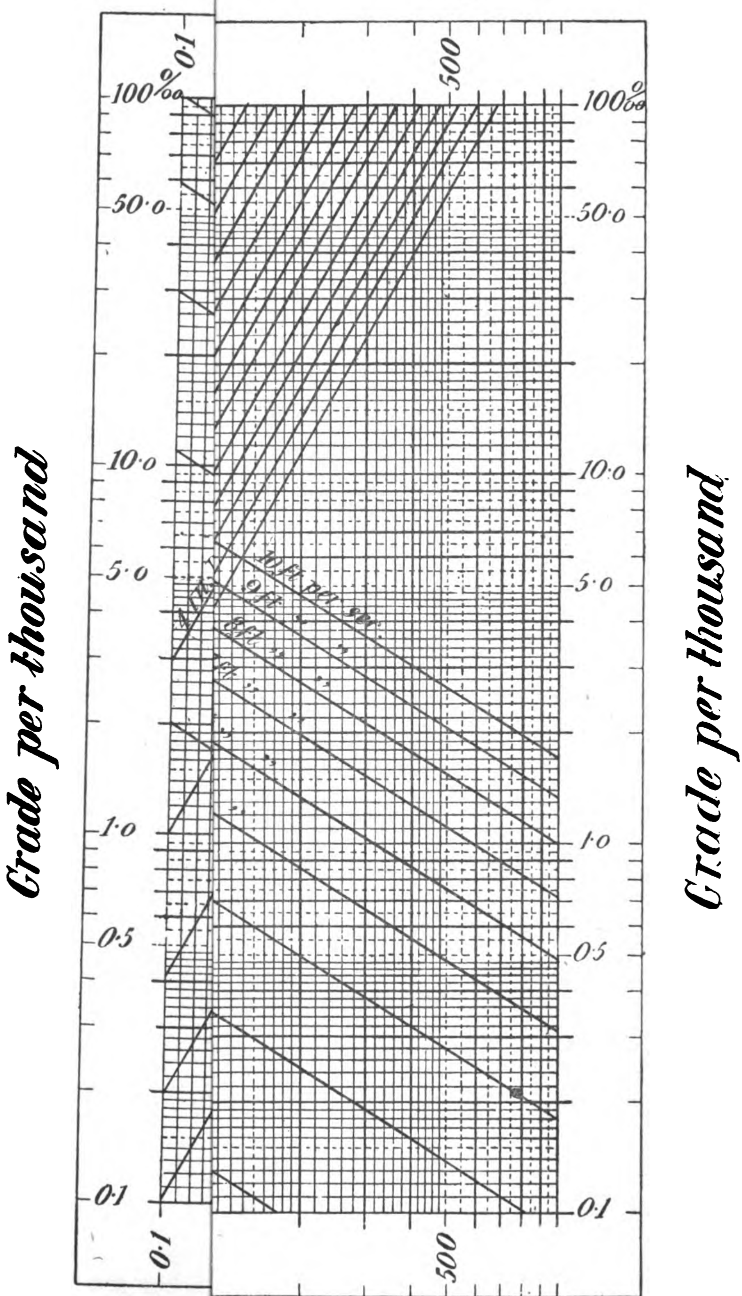
Coefficient = 0·00013



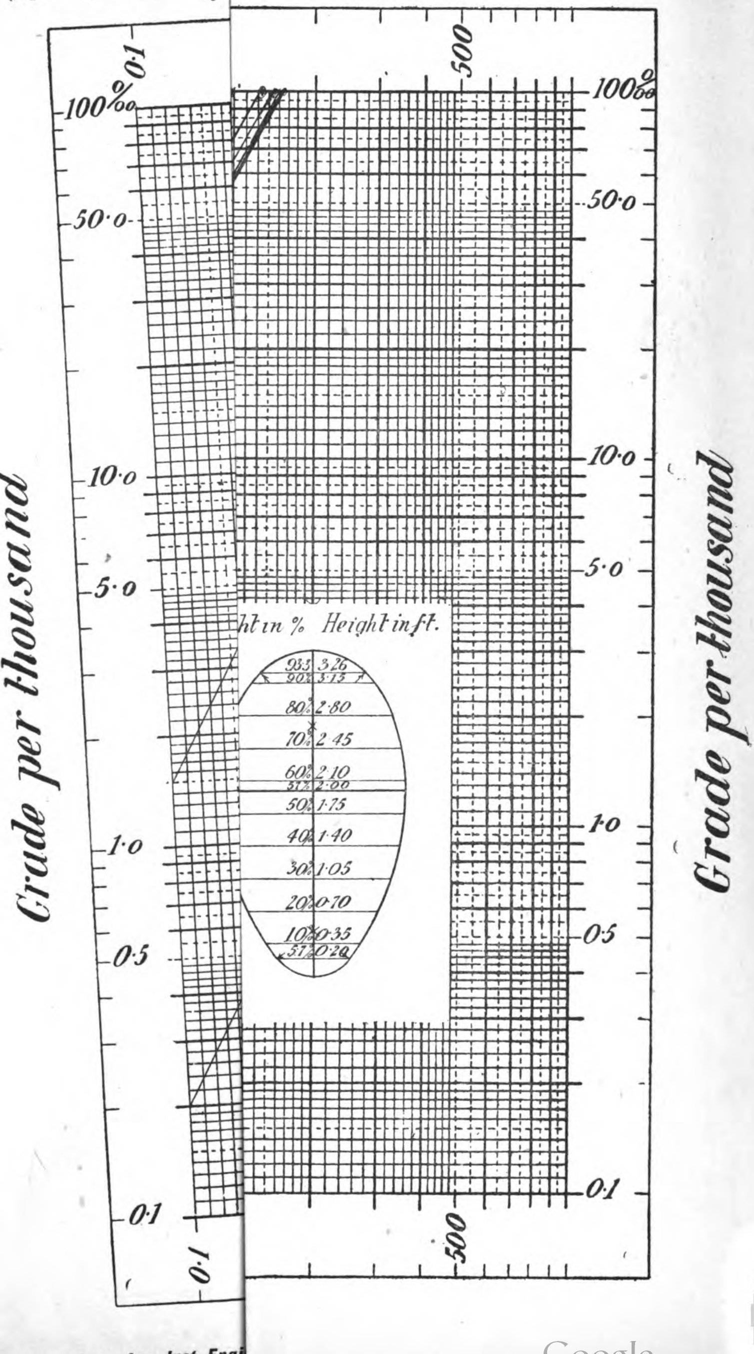
Pipe Se

Pipe Sewers



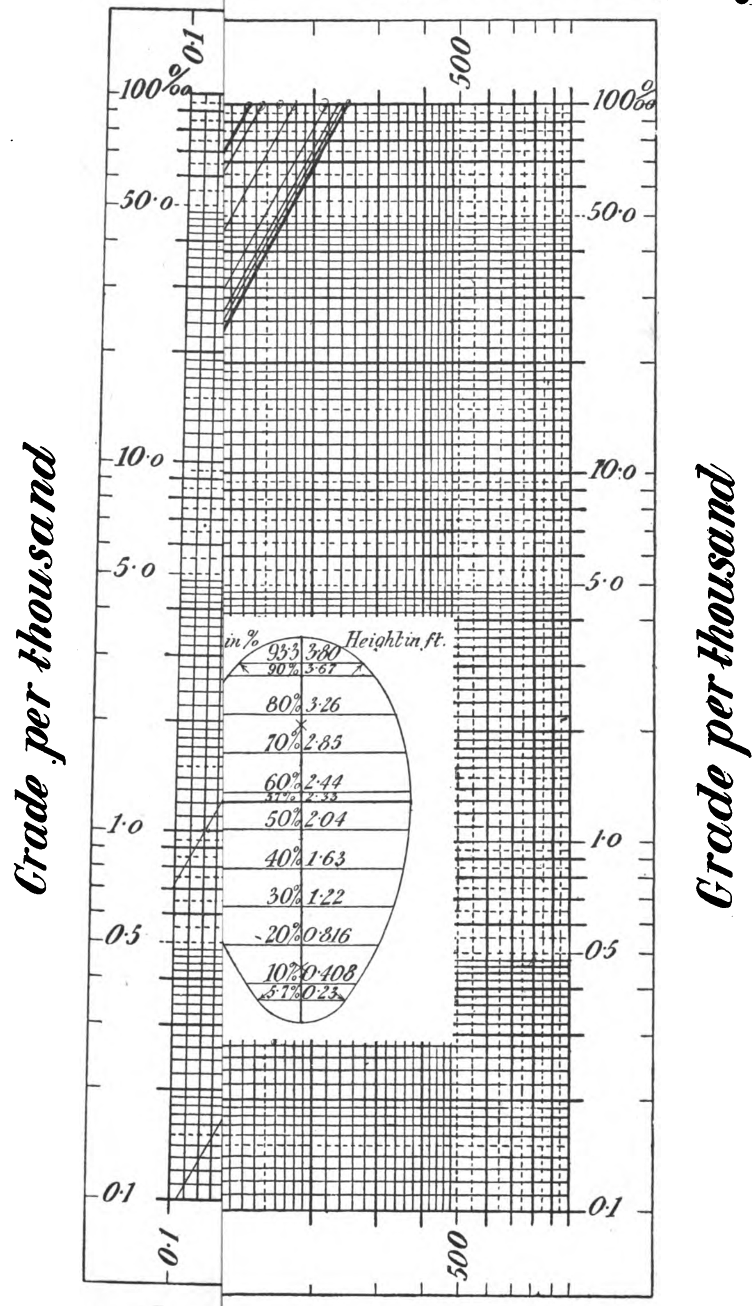
2'-0"×3'-6" Prof

2'-0"×3'-6" Profile



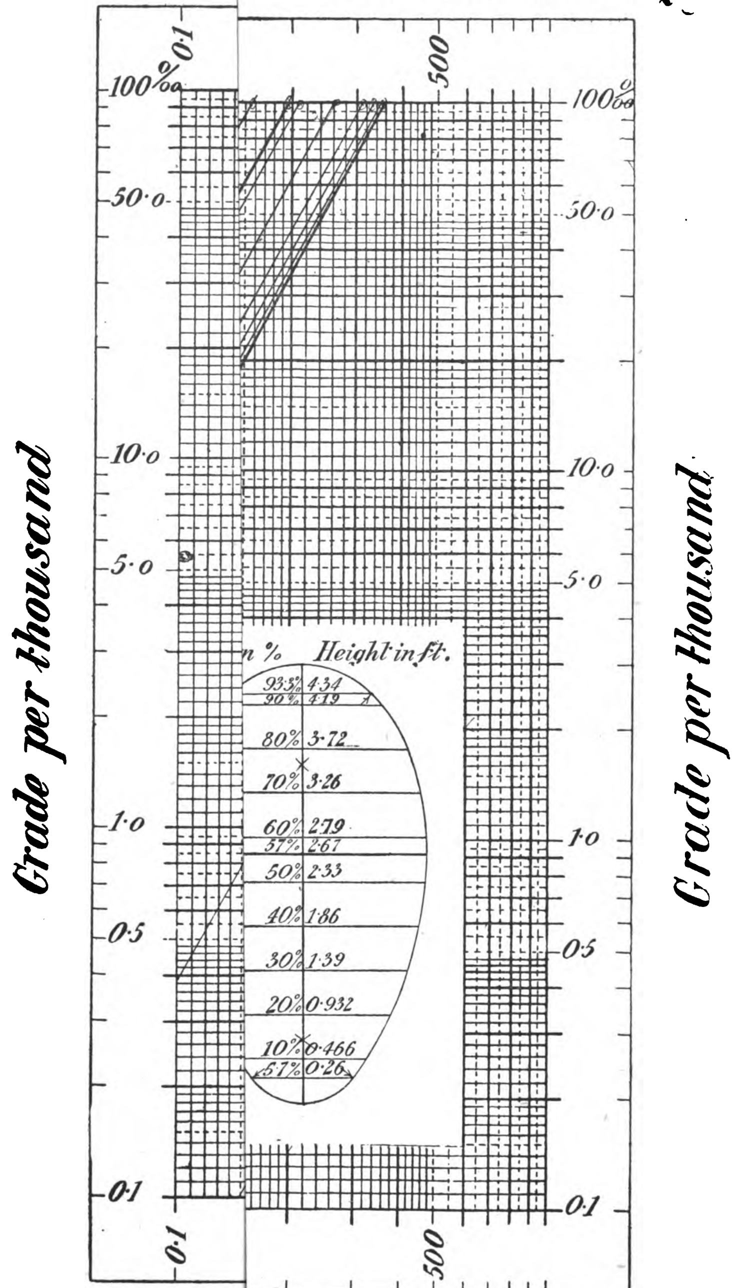
2'-4"x 4'-0" d

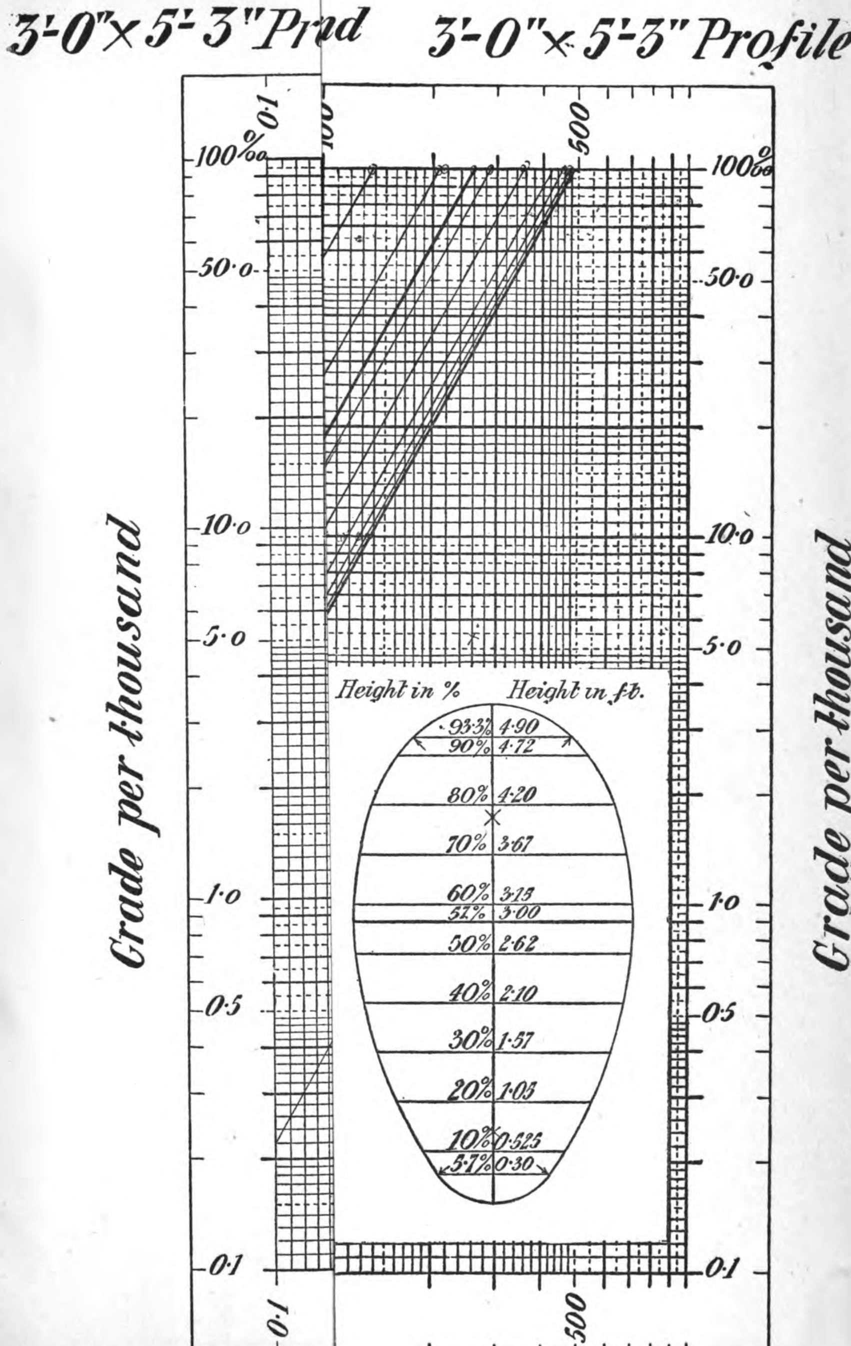
2'-4"x 4'-0" Profile



2'-8"×4'-8" P

2'-8"×4'-8" Profile

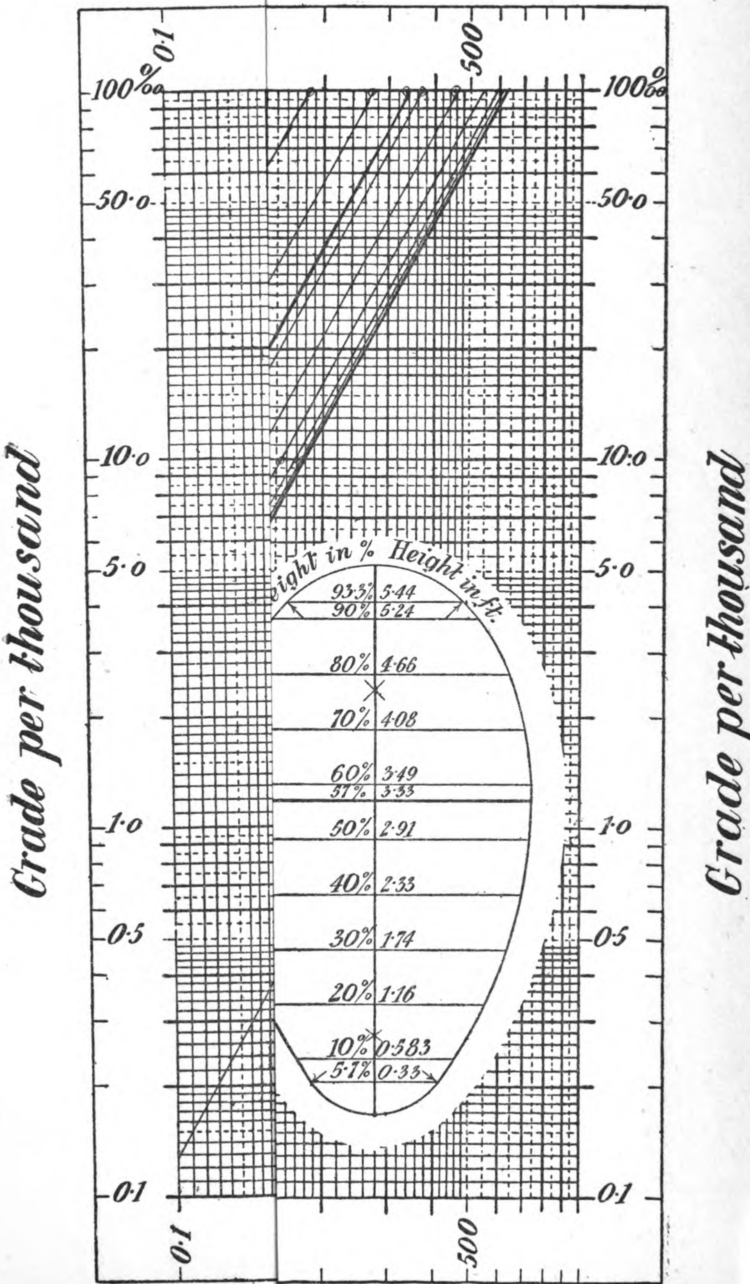




3'-0" × 5'-3" Prod
3'-0" × 5'-3" Profile
Grade per thousand
Grade per thousand
100‰
50·0
10·0
5·0
1·0
0·5
0·1
0·1
100
500
Height in %
Height in ft.
93·3% 4·90
90% 4·72
80% 4·20
70% 3·67
60% 3·15
57% 3·00
50% 2·62
40% 2·10
30% 1·57
20% 1·05
10% 0·525
5·7% 0·30

3'-4"×5'-10" Pr

3'-4"×5'-10" Profile



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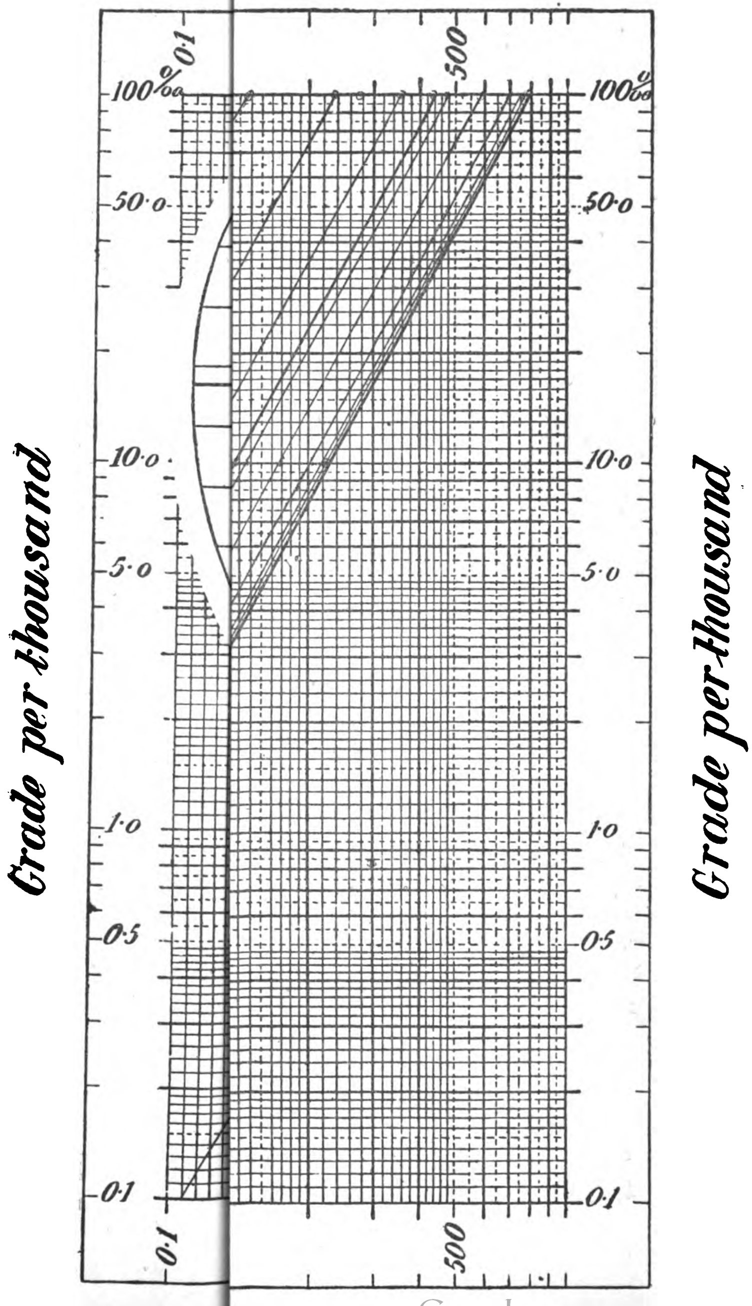
3'-8"×6'-5" Profile



4'-0"×7'-0" Profile

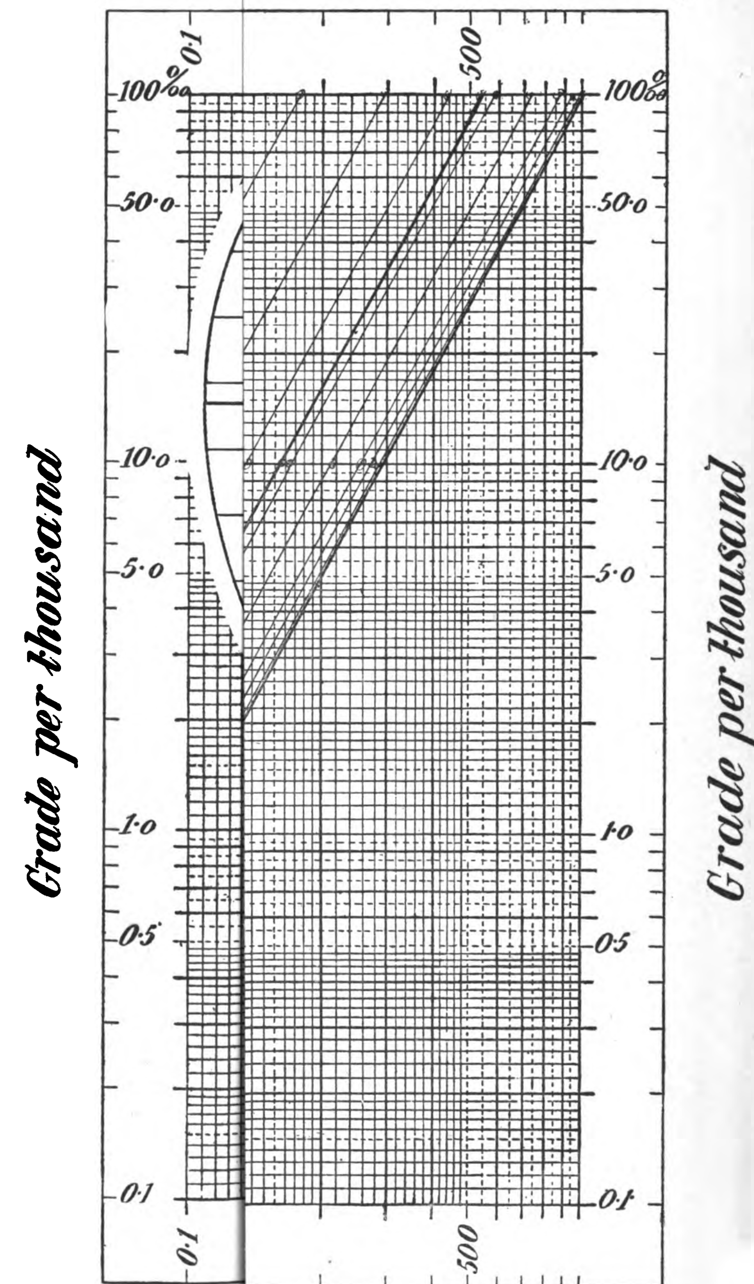


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PLATE 10.

Fig. 9. Pipe S

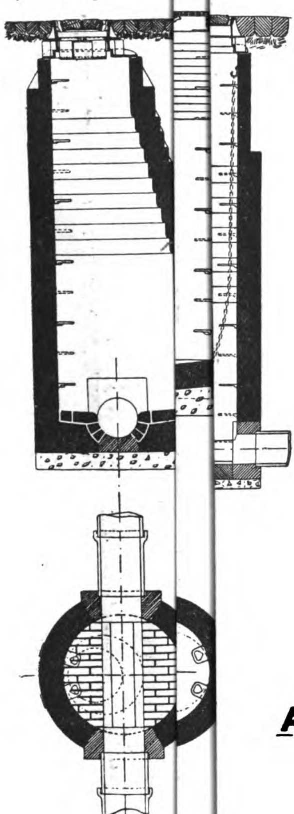

Fig. 13. Pipe Sewers.

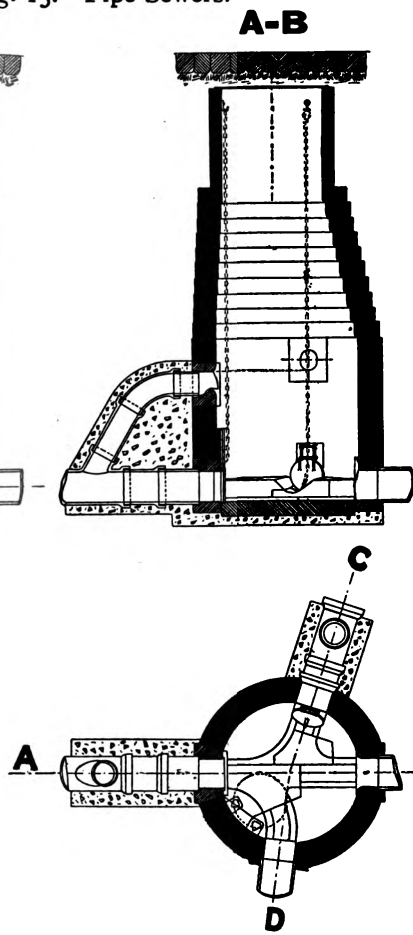

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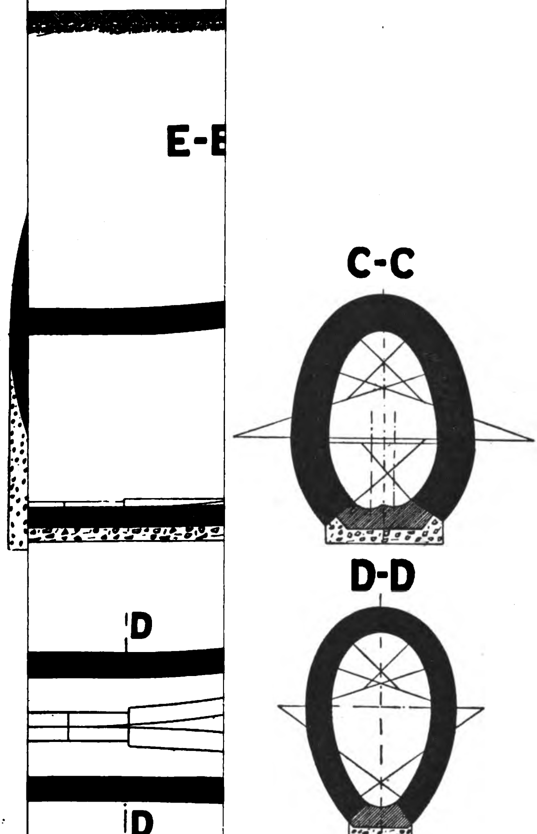
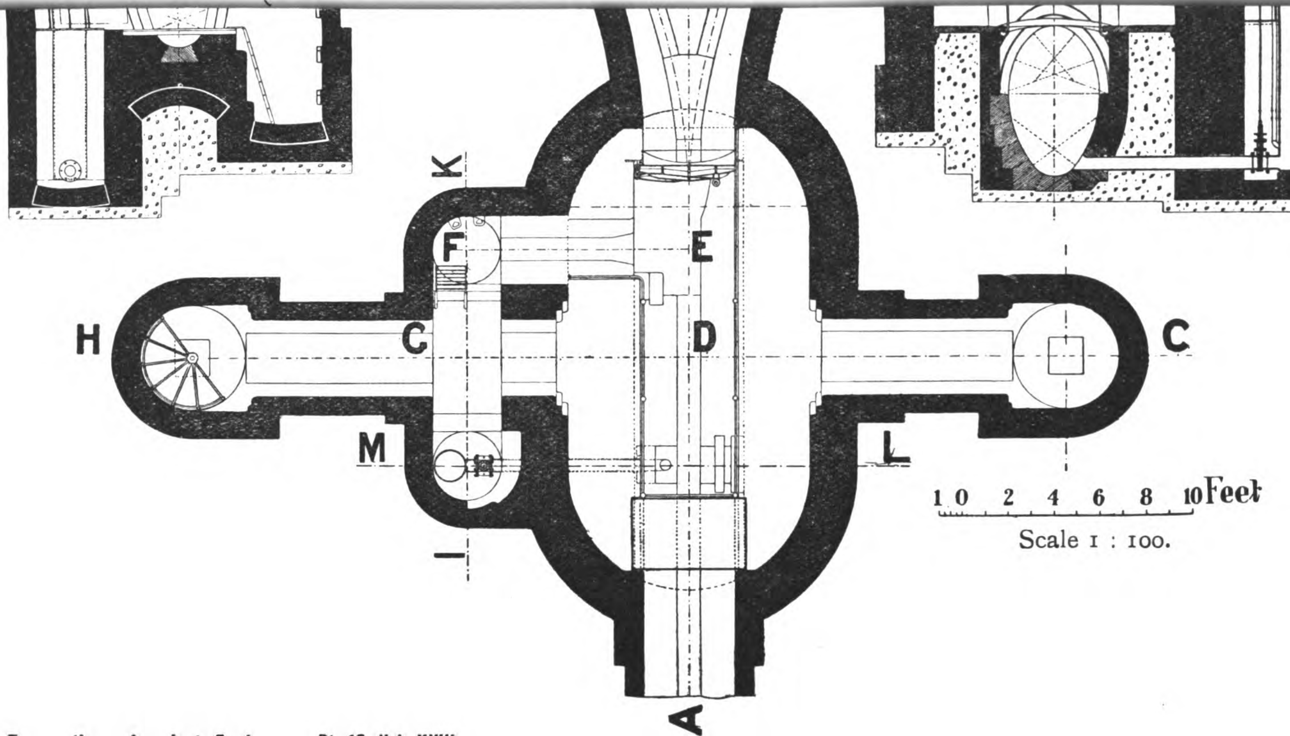
PLATE 12.




K
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1 0 2 4 6 8 10 Feet
Scale 1 : 100.

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PLATE 14.

Overflow at Bad Toelz.

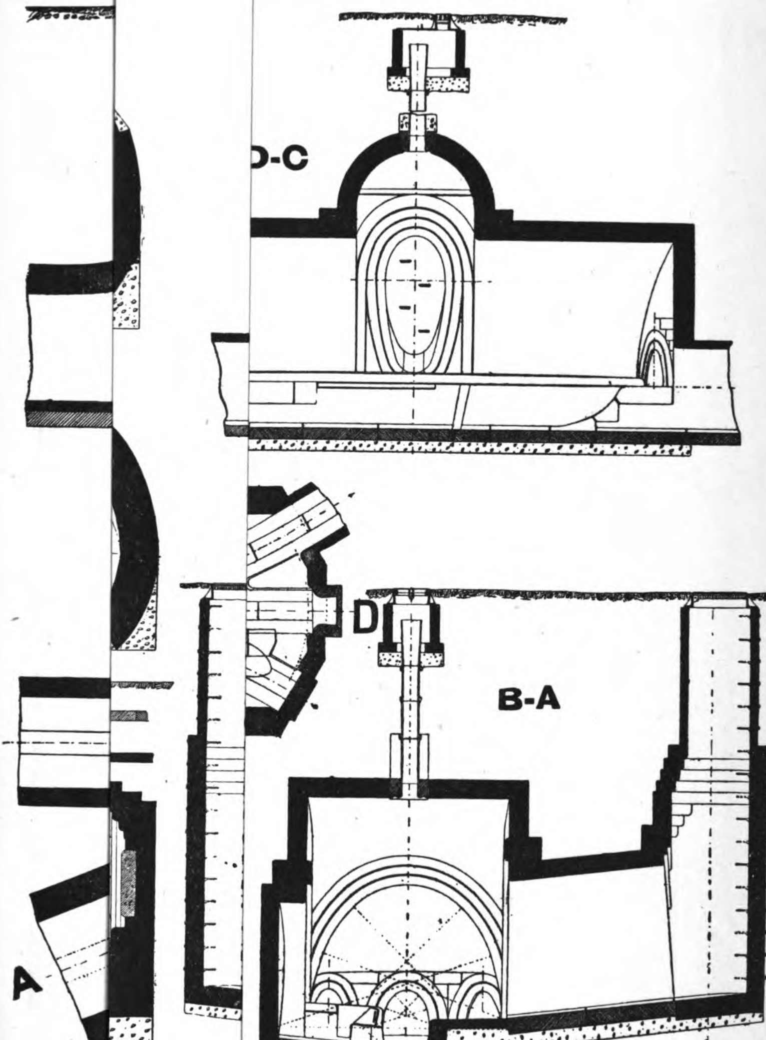

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Fig. 28.

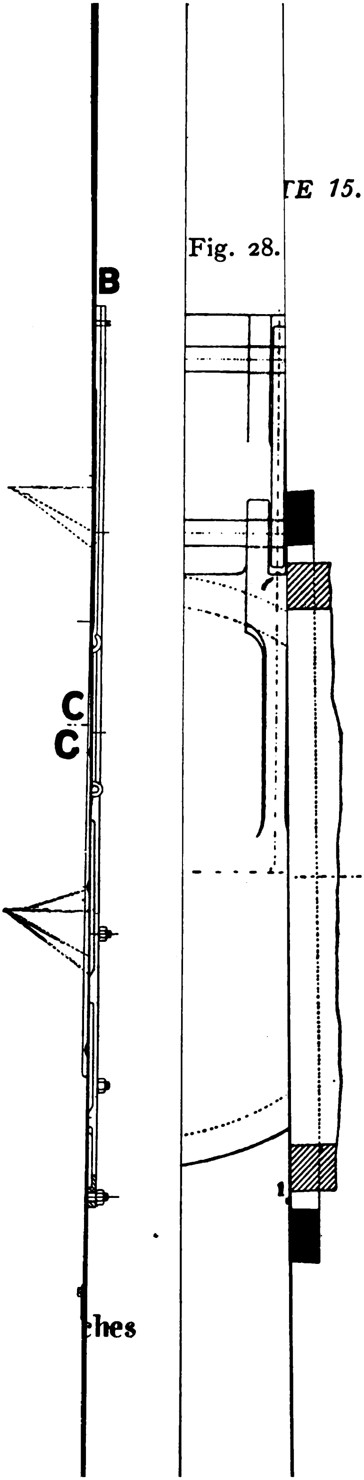

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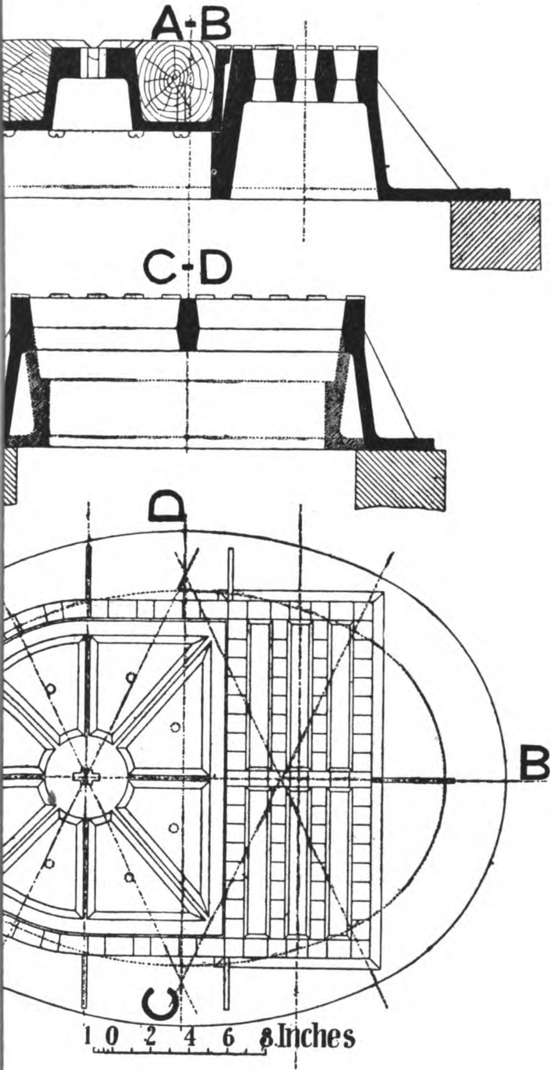
PLATE 17.

Combined Lamphole and Ventilation for Pipe Sewers.



Part 11. AUGUST, 1908. Vol. XVIII.

The Junior Institution of Engineers.

(Incorporated.)

President - - M. GUSTAVE CANET, M.INST.C.E.,
Past-President Institution of Civil Engineers of France.

Chairman - - FRANK R. DURHAM, Assoc.M.Inst.C.E.

Telephone—
No. 912 VICTORIA.

39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

6th August, 1908.

ANNOUNCEMENTS.

DURHAM BURSARY. Those intending to enter for the Durham Bursary, the conditions of which were announced in the May number of *The Journal*, are reminded that the Theses must be in the hands of the Secretary **not later than 1st September.**

Birmingham Local Section.

Members having friends at Birmingham and in the district are asked to bring the Institution under their notice with a view to their joining and receiving the benefits of the Local Section. The Hon. Local Secretary, Mr. R. B. A. Ellis, 67 Wordsworth Road, Birmingham, will be pleased to forward full particulars.

Membership.

The following are the names of candidates approved by the Council for admission to the Institution. If no objection to their election be received within seven days of the present date, they will be considered duly elected in conformity with Article 10.

Proposed for election to the class of "Member."

AMOR, GEORGE WILLIAM; Messrs. Deane and Beal, 676 Old Kent Road, S.E.

ARMISTEAD, WILLIAM REGINALD; Engineer's Department, Manchester Corporation Tramways, 55 Piccadilly, Manchester.

CANET, PAUL ADOLPHE; 22 Rue Octave Feuillet, Paris.

COOP, GEORGE SPARLING; Messrs. Erith's Engineering Co., 70 Gracechurch Street, E.C.

COWELL, HARRY; 11 to 15 Stamford Street, Blackfriars, S.E.

JOHNSON, WILLIAM PERCY; Overdale, Kelsall Hill, near Chester.

LINDSAY, WILLIAM JAMES; Power Gas Corporation, 39 Victoria Street, Westminster.

SEABROOK, WILLIAM HARCOURT; Messrs. Capel and Co., 168 Dalston Lane, N.E.

Proposed for election to the class of "Associate."

BOULTON, EDWIN; Estate Office, Ockham, Surrey.

HAWKINS, FRANK JAMES; Electrical Engineer's Department, St. Marylebone Borough Council, 19 and 20 York Place, Baker Street, W.

HAYES, MORGAN WILFRID; Public Works Department, H.M. Dockyard, Portsmouth.

Changes of Address.

BARR, Prof. A., Caxton Street, Anniesland, Glasgow; and Westerton, Milngavie, near Glasgow.

BRUNNING, E. J., 21 Melville Road, Barnes, S.W.

CARTWRIGHT, L. J., 80 Mayford Road, Balham, S.W.

COOKE, S. V., 32 Church Road, Wimbledon.

DOWNES-SHAW, A. H., Holmer House, London Road, Worcester.

GOODMAN, W. H., "Oakmead," York Road, New Barnet.

HUNT, D. N., "St. Teilo," Whitehill, Chesham, Bucks.

JAGER, S. C., 18 Moreton Avenue, Stretford, Manchester.

JONES, A. R., 17 Ouseley Road, Balham, S.W.

KINGSTON, S., The Vulcan Engineering Co., Barnes, S.W. [*605 Putney; "Vulcaloy," London.*]

LINDLEY, F. E. S., Coddington, near Newark-on-Trent.

MARTEN, J. G., c/o Mr. P. D. Marten, "Gleathorne," Parkhurst Road, Bexley, Kent.

MILLER, GEO. P., 10 Stoke Road, Shelton, Stoke-on-Trent.

MOORHOUSE, T. E., c/o R. Samuel, "Ivydene," Bay Road, North Sydney, New South Wales.

PENROSE, T., "Hazeldene," Wardle Road, Sale, near Manchester.

PEYRECAVE, G. DE, 16 Montpellier Row, Blackheath, S.E.

PUGH, L. W., 2A Mildenhall Road, Clapton, N.E.

ROBERTS, W. P., Public Works Department, Divi Pumping Project, Avinegudda P.O., Kistna District, Madras Presidency, India.

St. JOHNSTON, T. A., Francis Villa, 141 Earlham Grove, Forest Gate.

SETTI, S. V., Sub-Assistant Engineer, Water Supply and Stores Division, Bangalore City, Mysore Province, India.

SKEET, A., 37 Chryssell Road, Brixton, S.W.

STEVENS, H. C. M., 47 Radford Road, Lewisham, S.E.

TAYLOR, GEORGE, 219 Queen's Road, Peckham, S.E.

TRINDER, W. E., "Lynmouth," 36 Lady Margaret Road. Southall.

PERSONAL NOTES.

A. J. DENTON has been elected an Associate of the Institution of Municipal and County Engineers.

A. F. M. GATRILL is about to take a long sea trip for health, sailing on the 5th August by the S.S. "Miltiades," for the Cape and Australia.

L. HEYBITTEL is now with Messrs. Robt. Rogers and Co., Iron Foundry, West Row, Stockton-on-Tees.

JULIAN JULIAN, Borough Surveyor of Cambridge, contributed at the Nottingham Meeting of the Institution of Municipal and County Engineers some "Notes on Geology as applied to Municipal Engineering."

B. E. DUNBAR KILBURN has been elected Member of Council of the Chartered Institute of Patent Agents.

EARL MAIDEN left England on the 12th June, sailing by P. and O. "Himalaya," for Pekin, *via* Port Said.

JOHN MCCLURE has passed the Institution of Civil Engineers' examinations and has been elected an Associate Member.

F. G. MITCHELL has obtained an appointment with Messrs. Fraser and Chalmers, at London Wall Buildings, E.C.

THOMAS MOORHOUSE (from New Zealand) is now at Sydney with the New South Wales Powell Wood Process Co., who are erecting extensive works there.

R. W. NEWMAN is announced as one of the Lecturers in connection with the Vacation Courses in Agriculture, offered by the Rhodes University College, Grahamstown, from 6th to 25th July, his subject being "Irrigation." He has also been identified as a Member of the Local Committee, with the Sixth Annual Meeting of the South African Association for the Advancement of Science, which was held at Grahamstown, from 6th to the 11th July, and acted as one of the Hon. Secretaries for Section C (Engineering).

GASTON DE PEYRECAVE has returned to London.

WILLIAM W. SINCLAIR sails on 8th August as third engineer of the latest steamer of the P. & O. Line—the "Salsette" (6,000 tons, 10,000 I.H.P.; the fastest vessel in the Company's fleet), on her three weeks' maiden trip to Christiana, &c., previous to commencing the regular run to Bombay.

CHAS. A. SMITH is the author of a Paper on "A Method of Detecting Bending of Columns," which was included in the programme of the recent meeting of the Institution of Mechanical Engineers at Bristol.

CORRESPONDENCE.

THE DURHAM BURSARY.

Mr. R. W. Newman (Member) writes from Grahamstown, 5th July, 1908:—Mr. Swain's letter in the June number of *The Journal* is of more than passing importance; the question of the training of Engineers is always with us, conditions change as time goes on, and judging by the articles to which he refers in "The Engineer," conditions have very much changed since many of us served our time.

I for one should like to know, not so much what is the proper training for an Engineer, because on this point there is always diversity of opinion, *but what is wrong with the present methods of training*. Are not the present methods (much improved since my time) what are required? Is not the present works' course with classes, or for those who can afford it, is not the works' course as well as a college course suitable to modern conditions?

One thing I would impress on all those taking up civil engineering, especially those likely to go to the Colonies (and who can tell what one's ultimate destination will be?)—do not omit a period in the works. To be able to use your hands, when no fitter is within reach is invaluable; a period in the blacksmiths' shop, which is not I believe generally considered essential, will help you on many occasions. How many men know how to use tools but cannot fettle them; the knowledge of how to weld, if somewhat roughly, may keep things running and save the situation.

FROM THE STARTING PLATFORM.

THE EFFICIENCY OF PUMPS.

"Under low heads the efficiency of the reciprocating pump falls off considerably." Sentences similar to this are to be found in many books on pumping machinery and on hydraulics, but few engineers, either "junior" or "senior," seem to have any precise idea as to the définition of the word "considerably" in such cases, and the writer therefore thinks that the diagram herewith will be of interest to many, and may have the effect of putting "juniors" who have to do with pumping machinery more on their guard.

That it is necessary to be alert respecting such matters is evidenced by facts like the following:—

(a) Only a few months ago, the technical director of a prominent firm of pumping-engine makers assured the writer that his firm would guarantee over 80 per cent. efficiency on reciprocating pumping engines when lifting water less than 30 feet.

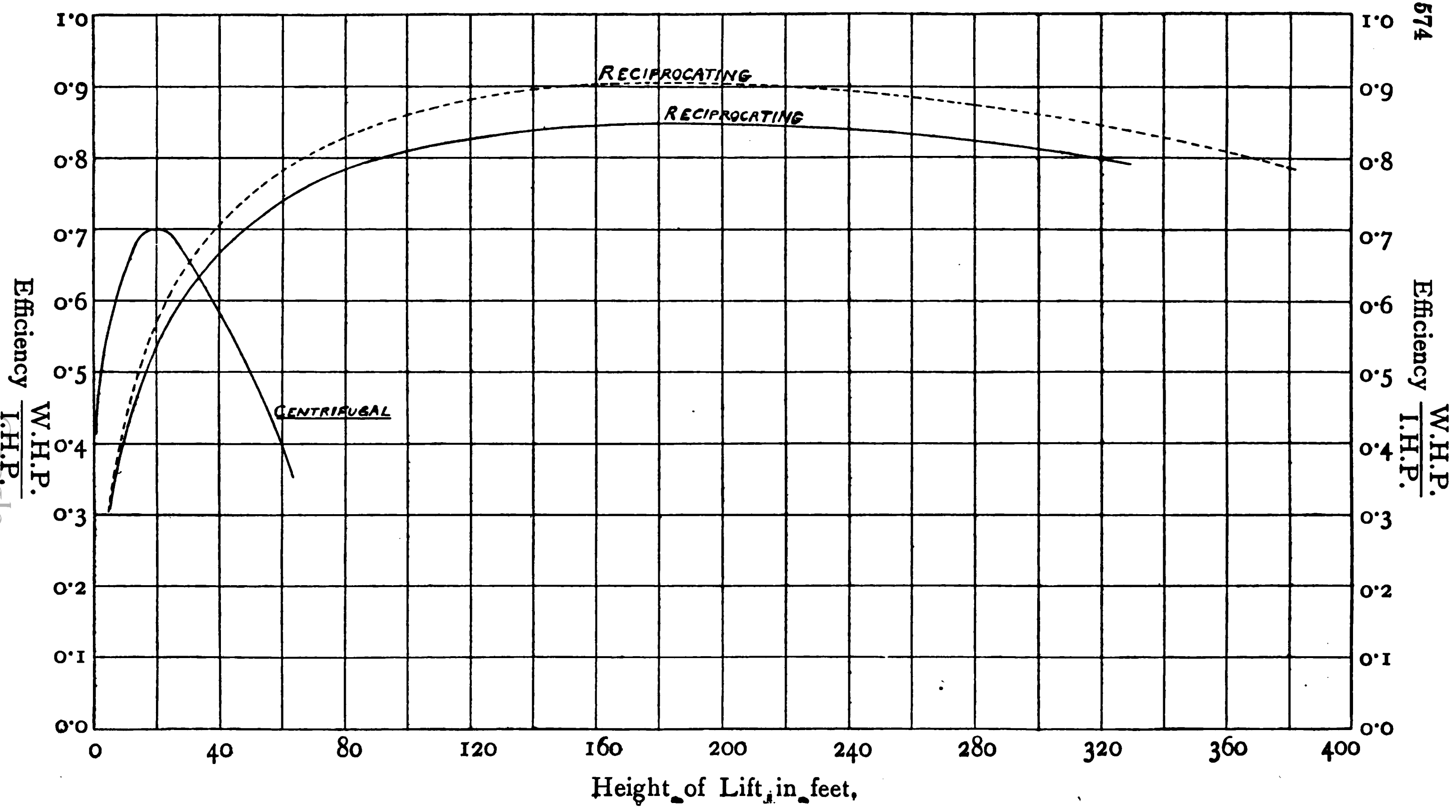
(b) Three or four years ago, some large reciprocating engines and pumps for a lift of about 20 feet were installed for a well-known public body, and, on completion, were tested by the makers and showed an efficiency of 86 per cent. to 104 per cent., which was considered highly satisfactory by all parties concerned!

(c) A few years earlier, trials were made of two different types of large pumping engines, lifting about 40 feet, and were recorded in the Transactions of the Institution of Civil Engineers. The efficiencies ascertained averaged 91 per cent., and again everybody concerned was quite pleased!

The efficiency of a pumping engine is of course the percentage expressed by $\frac{\text{Water Horse Power}}{\text{Indicated Horse Power}} \times 100$, where the figures relating to the quantity of water pumped have been obtained by actually pumping the water from or into a measuring tank or reservoir.

The practice of calculating the water horse power from displacement of ram or bucket and pressure recorded as existing in pump chamber by an indicator or pressure-gauge, though sometimes adopted by firms of position, is quite unreliable, and the printing and publishing of such efficiency figures without explanation of the methods used in obtaining them is to be deprecated. Every engineer will agree that the actual delivery of a pump will (in all ordinary cases) be less than the gross displacement by some percentage depending on the type of valve, number of strokes per minute, &c., but some may incline to think that the pressure obtained from an indicator diagram, or from a pressure gauge, may fairly be used in calculating water horse power, and it is therefore well to point out that such pressures are liable to be much affected by surgings and pulsations due to the momentum of the water, and by the friction of the water in the small pipes used in connection

EFFICIENCY CURVES OF PUMPS FOR LIFTS OF 10 TO 300 FEET.



with gauges, &c. Also, such diagrams and pressure records may even be approximately correct for one side or corner of a pump chamber, but may be very far wrong for other portions of the same chamber. The only safe way is to measure the water by means of a tank or reservoir.

In laying down the curves on the accompanying diagram the writer has tabulated the figures obtained at a large number of trials which have been reported in the Transactions of the Institutions of Civil and Mechanical Engineers, and in the technical press, during the last thirty years, but has rejected all in which the water was not actually measured as above described. The upper dotted curve indicates the highest efficiencies that can be reached in practice—efficiencies that require for their realisation very large pipe and valve areas, and long strokes with few reciprocations per minute. The lower curve (full line) indicates good ordinary practice with valves and all working parts in perfect order. It will of course be understood that in ordinary work very few pumping engines come up even to the efficiencies indicated by the lower curve.

The curve for centrifugal pumps relates only to plants in which the water was raised to the full height by one impeller, and no guide vanes were fitted in the casings surrounding the impellers. Owing to the fact that each centrifugal pump gives its highest efficiency at one definite speed of revolution, it is necessarily not such a reliable guide to highest practicable efficiency as is the curve for reciprocating pumps. But the curves are quite accurate enough to indicate certain general conclusions, viz.:—

(a) That the greater the head against which a reciprocating pumping engine works (within certain very wide limits) the greater will be the efficiency, a conclusion which also follows necessarily from the fact that the friction in such an engine is practically independent of said pressure. Some engineers are of opinion that maximum efficiency is reached at about 200 feet head, and that the curve then begins to fall again as indicated on the diagram, and there appears to be some evidence in favour of this view.

(b) That below say 40 feet lift a reciprocating pumping engine is a mistake, unless of very small size.

(c) That for heads of say 10 feet to 40 feet a centrifugal pump will give a higher efficiency than a reciprocating one.

Where the water to be pumped is free from weed or other foreign matter, pumps with guide vanes, or pumps fitted in series, may be employed, and good efficiencies obtained up to very high lifts, but in dealing with sewage, &c., such pumps are quite inadmissible.

Where sewage has to be lifted, the absence of valves, &c., gives the centrifugal pump a great advantage, as to provide for the frequent stoppages required for overhaul of valves, when reciprocating engines are used, more spare units must be arranged for than when centrifugals are used.

It should also be noted that the advantage of the centrifugal over the reciprocating pump is more marked as the quantity of water to be handled increases.

Below lifts of say 8 feet some other water-raising appliance, such as a scoop wheel, or Archimedean screw, will give a better result than can be obtained from a centrifugal pump.

To obtain a really high efficiency with reciprocating pumps it is important to use the longest possible stroke, and to keep the reciprocations per minute down to the lowest figure permissible; but it must be evident that, when these conditions are complied with, the result will be a large and costly machine in a large and costly house, and that, in consequence, the cost per million gallons raised one foot, when interest and sinking fund charges are included, will be high, in spite of the high mechanical efficiency and of the fact that the large slow-moving engine will cost less for maintenance than a smaller engine working at a higher speed. So that here, as in most other engineering problems, there are two antagonistic efficiencies to be dealt with, and it is the business of the engineer to arrive at the compromise or solution that will give the best financial result, which is, after all is said and done, the only true test of "efficiency."

H.M.R.

OBSERVATIONS IN GENERAL.

Our Summer Meeting of 1908 in France has passed into history, but in order that some impressions of those who attended could be kept on record in *The Journal* a request was circulated on the return of the members of the party, for a few lines indicating what their impressions had been. The following were received in response thereto:—

* * * * * *

"Fancy asking an enthusiastic Junior to try and give his impressions of any portion of the visit in about fifty words! However, PARIS—Our Hosts and Hostesses, the Institution of Civil Engineers of France, Paul and Albert Canet and the Ladies, Grand Hotel, Boulevards, River Seine Excursion, private view of the Chamber of Deputies, with the Ladies at Versailles, Sugar Refinery, memorable evening at the Pré-Catelan Restaurant, Flying Machines, Eiffel Tower, Metropolitan Railway, the charming people we met—all created the happiest of impressions which will long remain."

* * * * * *

"A first impression on visiting the works we had the privilege of seeing is likely to lead one to the conclusion that our French friends are ahead of us, but visits such as made by the Institution give opportunity for only a very cursory insight into methods and results, and although there is much for an English manufacturer to learn, my opinion is that the conditions prevailing abroad, both in regard to material and labour, are in many ways less favourable for rapid and economical production than in England."

* * * * * *

"An admiration for the French, as a people, is materially enhanced by a visit to their Capital. How grand the scale upon which the city of Paris has been planned; how magnificent the buildings, rising upon all sides."

* * * * * *

"The electrical man, when observing the artificial lighting of the streets, shops, &c., of Paris, is rather impressed and disappointed by

the apparently indispensable part gas takes in this service. Nearly all the establishments, except the very best, still have liberal supplies of incandescent gas jets side by side with their electric fittings and the authorities do not seem to have felt justified in removing the gas standards from the principal thoroughfares which are well illuminated by arc lamps. There are two probable reasons for this: high rate of charges for electricity and unreliability of supply; and when one reflects upon the almost exclusive use of electricity in the best parts of our West-end and City, he is inclined to consider London as ahead of Paris in this particular direction."

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"Comparisons are odious, but despite this I do not think anyone who had the pleasure of visiting both Glasgow and Paris with the Juniors could help comparing dull, depressing, smoky Glasgow, with bright, merry and beautiful Paris. How is it that such curious and national differences still exist? The difference for instance between the flaring gin palace and the artistic boulevard café; the ragged, shoeless and dirty poor of Glasgow and the neatly but plainly clad Parisian workman spending his Sunday with his wife and family in the Bois de Boulogne; between Glasgow's solidity and Parisian effervescence?"

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"I was much impressed by the great kindness and hospitality of our French friends, and by the trouble taken by the various engineers in so courteously explaining the details of manufacture at their works. The organization at the big factories was an object lesson to all."

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"Our Summer Meeting in France was a very successful one, and it is to be regretted that more of our members did not share in it. The visits to works were extremely interesting and instructive."

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"I could not help feeling that the advance of mechanical traction has filled the main avenues of a most beautiful city with an atmosphere redolent of burnt petrol fumes, and that the Parisians might well consider whether the advantage of increased speed of locomotion was worth obtaining at such a cost."

"The landscapes between Dieppe and Paris, the river bridges, Eiffel Tower, the Creusot works and the organization of our visit there, the quantity of English machinery noticed in various manufactories, the aeroplanes, also the fine boulevards and open spaces favourably impressed me; while my observations in relation to railway travelling and rolling stock, control of street traffic, sanitary arrangements and ventilation had the opposite effect."

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"I thought the sons of Monsieur Canet worked very hard indeed to make our visit enjoyable, and they undoubtedly succeeded. The great kindness and geniality shown at the splendid entertainment at the Pré Catelan and that of the French Institution of Civil Engineers much impressed me. As to observations in general I should like to put in a plea for the poor Parisian horse; judging from his miserable appearance and the frequent applications of admonition he experiences, his lot seems anything but a happy one."

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"Paris is so planned that one is able to obtain long uninterrupted views of its fine streets, which converge in such a manner, with multitudinous masses of architecture, relieved by avenues of well-established trees, as to permit of grand perspectives. La Seine—a moderate stream—is spanned by many excellent bridges, in the design of which the engineer, architect and sculptor have so worked in harmony as to produce most pleasing results. As to materials used in these particular constructions, to me the old stone and cast-iron bridges appeared more beautiful than the modern erections in steel."

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"Imagine a grassy lawn on a cliff overlooking the blue waters of the English Channel. Away to the left the cliffs dip down till they mingle with the white houses, the piers, and the shipping of Havre. Beyond the broad estuary of the Seine lies Trouville just discernable, and from thence the long coast line, clothed in gold and purple in the rays of the sinking sun, stretches out towards the broad Atlantic. On the lawn on the cliffs are the last of the happy band of Juniors, taking tea after exploiting the engineering wonders of the neighbourhood at the close of their eventful holiday. The panorama is magnificent and forms a fitting *finale* to the ever-changing scenes of the last fourteen days. From Havre and Trouville, and the sunlit shore, the eyes of the party wander across the waters, and their hearts go out to the motherland beyond, where the morrow

will see them once again, and so to France the Juniors say not *adieu*, but *au revoir*."

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Sir W. H. White (Past-President) has been elected Chairman of the Council of the Royal Society of Arts, and also President of the newly formed Institute of Metals.

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The Hon. W. Pember Reeves (Vice-President) has cabled to New Zealand his resignation of the High Commissionership in order that he may take up the post of Director of the London School of Economics. Mr. Reeves is a member of the Senate of the University of London and has already been connected with the London School of Economics as member of the governing body.

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It is interesting to observe that of the five British delegates appointed by the President of the Board of Trade to attend the International Conference on Electrical Units and Standards, which is to be held in London, opening on the 12th October, three are Vice-Presidents of our Institution, namely, Lord Rayleigh, Professor J. J. Thomson, and Dr. R. T. Glazebrook; the other two delegates appointed being Sir John Gavey, and Mr. A. P. Trotter.

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Mr. Trotter will be remembered as the author of the Paper on "Acceleration and Accelerometers," which he read to us in March, 1906, and also in connection with the visit we paid, about the same time, to the Electrical Standards Laboratory of the Board of Trade in Whitehall.

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We notice that Mr. A. T. Walmisley (Hon. Member) has been appointed Lecturer on Waterways, Harbours and Docks, in connection with the Civil Engineering and Surveying section of the Faculty of Engineering at University College, London.

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It is hoped there will be a good number of entries in competition for this year's Durham Bursary. Those between the ages of 20 and 22 are eligible, the qualification being the writing of a thesis on some engineering, technical or scientific subject, chosen by the candidate. September 1st is the latest date for the receipt of the thesis. Full particulars were given at page 413 of *The Journal* for May last.

DISCUSSION ON "THE DESIGN OF A SEWER."

MR. RONALD J. FRANCIS (Member), in proposing a vote of thanks to the author for his excellently prepared paper, said the subject dealt with was not only of great interest to engineers in general, but was of special interest and value to engineers engaged in the construction of sewers, and the designing of sewage schemes. It was particularly welcome because it gave an account of Continental practise which English engineers so rarely had the opportunity of discussing under such favourable circumstances, the author having been occupied on sewage schemes in Germany for some years. The value of the paper was greatly enhanced by the accompanying tables and diagrams, the preparation of which must have entailed a great deal of thought and trouble. He quite agreed with the author that the brickwork should be of the best possible quality. Engineers, and others not familiar with the building and maintenance of sewers, on being conducted through new sewers in large towns and cities, often remarked on what they regarded as unnecessary expenditure, and on the extravagance of public bodies. The best reply to such an observation was that engineers who have spent their lives in charge of main drainage work, and have had experience of the cost of maintenance of sewers, are of the opinion that the materials and workmanship should be of the highest quality.

With reference to the details, $\frac{3}{8}$ inch for face joints appeared to be rather large. In the London main sewers it was customary to work $\frac{3}{16}$ inch face joints which necessitated well-shaped bricks, and that each brick should be gauged by hand before use; $\frac{5}{8}$ inch collar joints, which of course was the thickness of mortar between the rings of brickwork, were used.

With regard to strangers' galleries in the sewers, he rather felt them to be doubtful luxuries, and asked in what way such facilities for inspection benefited the community, and whether they were taken advantage of by the people for whom they were intended. An experiment to awaken the interest of the public in municipal works was tried by the late Sir Joseph Bazalgette when he was laying out the main drainage of London about fifty years ago. He endeavoured to build the public works connected with the main drainage in such a way that the people of the

Metropolis should take an interest in and visit them. This was specially noticeable in the Abbey Mills Pumping Station at West Ham. A great deal of money was expended in designing and decorating both the building and the machinery, with the expectation that Londoners would take a pride in and visit these works. That expectation had never been realised, for at the present time, with the exception of engineers interested in sewage matters, only those occupied on the main drainage system of the Metropolis seemed to have taken much notice of the works in question.

MR. ALLEN VICKERS (Member), in seconding the vote of thanks, expressed his personal thanks to the author for a very interesting paper. It was a model of conciseness, of great value to the student, and one might almost add, a text book on sewer construction. The speaker favoured the design of the egg-shaped sewer, and was sure, when examining a 3 feet by 2 feet sewer, he would be very glad of the extra six inches in height. In regard to the use of invert blocks, there would be no difficulty if the blocks were made true and hard, but it was impossible to cut, shape or rejoint salt-glazed stoneware, and unless the joints were true they were often wider, and if warped were far more unshapely than an invert made of bricks closely jointed, of the proper radii; moreover, they were more likely to arrest the heavier matters in the sewage. It should also be borne in mind that the use of the trolley in cleansing wore away the glaze, and an instance came under his personal notice where upon examination, he found the top section of the blocks had broken through and formed pockets which were full of solid matter. He had no doubt the author would say that the material was not good, and he would be right, but still the fact remained, and the use of a cellular block would always present the same difficulty if damaged.

With reference to flap valves, he (Mr. Vickers) suggested that when of large size they should be made in two parts and hinged horizontally, so that, in case of men being caught in the sewer by floodwater, they could use the upper half and escape while the other half might run full bore. This greatly increased the element of safety. The idea of the telescopic principle for road covers appealed to him as being very good. It provided a simple method of regulation to road levels, and would be of considerable

advantage on macadamised roads. He could not agree with the open system of ventilation, at least in London, and where dealing with old sewers. Of course if an ideal sewerage system could be laid down such as that outlined by the author, there was no doubt that the open system was right, but it was hardly to be expected that that degree of perfection would ever be attained in London.

MR. R. S. LINDLEY (Visitor) who, as brother of Mr. W. H. Lindley, Past-President, was warmly welcomed and asked to speak, expressed his thanks for the kindly and courteous manner in which he had been introduced and received. If, as an outsider, he were permitted to make a few remarks, his first duty would be to congratulate the Institution upon the able, instructive, and interesting paper they had just heard from Mr. Durham.

One point that struck him as not quite clear in the paper was that the selection of the intercepting or the radiating system was not absolutely at the discretion of the engineer, but depended upon local circumstances ; the City of Frankfort, as shown in the diagram, Fig. 3, adapted itself distinctly to the intercepting system, whilst the City of Elberfeld, intersected by many secondary valleys draining into the river Wupper, could only be treated by the radiating system.

The paper opened a wide field for discussion of technical details, but what appealed to him principally in it was the stress the author laid upon the necessity of a careful study of the future requirements of a district in designing its sewerage system ; this was in his (Mr. Lindley's) opinion, one of the principal sources of the success which he thought might be claimed for the work carried out by his father and his brother and those working for them on the Continent. He was afraid that foresight was not always evident in the work carried out in this country, from experience which had come under his own notice, such as the necessity of taking out a sewer that had only been built some five or six years and laying it at a flatter and less advantageous gradient, in order to drain some houses that had been built a little further along a roadway than had "originally been anticipated," and the case of a sewer built along a roadway following the line of contour, at a sufficient depth to drain the houses on the upper but not on the lower side ; the houses which were now being built on the lower side had to resort to cesspools for their drainage, thus re-establishing all the old evils, for the avoidance of which

the public authority had incurred the great expense of a "drainage system." This important question of depth reminded him of an anecdote he had heard his father tell of Mr. Telford, who was considerably his senior, saying to him, "Never be afraid of the earth, Mr. Lindley, cut into her as deep as you like, she will never hurt you!"

Of course English practise differed in many respects from that of the Continent; whilst here every house was practically a tenement of its own, the average Continental house was a barrack of tenements, built more or less all round an inner court; whilst therefore abroad a house drainage system was an elaborate work, costing a considerable sum, necessarily discharging to the sewer in the street or road in front of the house, and involving a comparatively small additional outlay for cutting under the house, at home where the house was built with all its sanitary establishments placed more or less compactly at the back, the drainage work was a small affair, to which cutting under the house would add a considerable proportionate outlay, and the convenient system of carrying the collecting sewers under the private ground behind the houses had been resorted to. Apart from the disadvantage of partial withdrawal from public control of the public sewer placed upon private ground in this manner (which could be and is partially met by legislation) there were further objections to this system in the following respects: firstly, the loss of the great advantage of through ventilation from sewer to sewer, by the creation of "dead ends," which would at times smell objectionably, and being blocked up to prevent this would cause trouble and possibly danger to health; secondly, the loss of the great advantage of through flushing from one sewer to another, entailing the necessity of introducing water directly from the mains for flushing purposes instead of using the sewage for flushing the sewers.

Finally, he wished to say a word in strong approval of the advantages given by the "strangers' galleries," touched upon by a previous speaker; he had always found them much appreciated.

MR. P. J. WALDRAM (Past-Chairman), suggested that in rural districts where developments were extremely slow and where the water supply was scanty, sewers which were too large were worse than those which were too small. A 6 inch pipe would

take a considerable amount of village sewage and would be kept clean by a flush that would leave a 9 inch or 12 inch pipe constantly foul. The chance of blocking a 6 inch pipe had to be considered, but it should be recollected that it would have to be blocked by substances which had already passed through the 4 inch house drains and traps. With regard to obtaining statistics relating to rainfall, he could testify to the courtesy and consideration one received when making enquiries from the officials of the Royal Meteorological Society.

In a written communication, Mr. Waldram, after expressing his high appreciation of the paper, writes:—" Very economical flushing of pipe sewers can be effected by damming back the flow at different manholes by balls or sliding boards, and allowing it to discharge suddenly by the withdrawal of the boards or ball by means of a chain. I agree with the author that it is sometimes a little awkward to hold a staff on an ordnance bench mark, but there are many such marks, and if one be obliterated or awkward, another can almost always be found not far off. May I suggest that it is very desirable to pick up as many ordnance references as possible when taking preliminary levels, both bench marks and road levels. Such references are not only a constant check on accuracy, but they enable the Local Government Board officials who have to examine the plans to readily check the levels.

I should like to enquire whether with pipe sewers it is customary on the Continent to leave and bury junctions for future connections, or to cut the pipes and put in saddle junctions as required. Both systems are practised in England, and both have their disadvantages. The insertion of junctions with accurately kept records has, I believe, the balance of popularity.

Concrete pipes have been largely used for storm and surface water sewers, piping in ditches, &c.

With regard to mechanical ventilation, it should be recollected that a very slight pressure or vacuum suffices to blow the water seal of house traps. Great difference of opinion exists on the question of the ventilation of sewers. One thing, however, appears to be quite certain, viz., that roadway inlets frequently become outlets on very slight provocation, and it seems therefore the wildest folly to afford sewage, under the guise of ventilation, every opportunity and inducement to give off

exhalations which might be reeking with typhus germs, and to provide manhole openings through which school children playing in the road can inhale them with ease. I would venture to make the revolutionary proposal that, at least with pipe sewers, ventilation is unnecessary and even wrong except in so far as it is necessary to prevent the accumulation of air pressures which could blow the house traps. What is the advantage of passing volumes of air over sewage and returning it to the atmosphere of crowded towns either at the street level or near attic windows? If it be for the sake of purifying the sewage I should like to have the expert opinions of anaerobic bacteria on that point. Ventilation is of course desirable for the sake of sewer men working in large brick sewers, but would it not be better that sewer men should, if necessary, work in oxygen helmets rather than that poisonous (and deadly poisonous) gases should be deliberately discharged into the air of crowded towns, especially at street level? "

MR. R. MARSHALL (Member), referring to cement jointing of pipe sewers, also to the concrete bed under them, said that most building bye-laws rendered this obligatory. He pointed out that ferro-concrete was being used in the construction of large sewer conduits, and asked the author to state whether his objection to this method arose from considerations of possible disintegration of the concrete due to the action of the sewage. He also asked whether it was not possible to protect the concrete by an internal facing of some kind, and what means were adopted for rendering the brick sewers water tight? As regards iron pipes, the tendency seemed nowadays to be in the direction of using cast-iron pipes and connections for house drainage work.

MR. C. T. ALFRED HANSSEN (Visitor), expressed his high appreciation of the paper. He had followed the work of Mr. W. H. Lindley in Germany with great interest for many years; he knew that excellent sanitary work had been done by him, and that he had been ably seconded by his assistants, among whom Mr. Durham had held a prominent position. He could not, however, help doubting the wisdom of the almost exclusive adoption of the combined system. This system was a necessary evil in towns like London, where large areas were situated below the high level of water in the river, and therefore would be subject to inundation unless rain water was removed by pumping. It

was an excellent system in towns where the whole of the sewage could be discharged by gravitation without causing any nuisance, and after the completion of the main drainage of London it was introduced into most towns in England, but it had resulted in an intolerable pollution of nearly all English rivers, and of long stretches of the foreshore in the vicinity of seaside towns. Since the passing of the Rivers Pollution Act, which compelled towns to purify their sewage and rainfall to the extent of six times the volume of the sewage proper, the combined system had become an expensive luxury in England as few towns could perform such a purification without pumping the sewage, and to put down and to work pumping machinery and purification works six times larger than necessary was a very serious consideration for most towns. The whole tendency in England was therefore to divert the rainfall as much as possible from the sewers, and to let it flow to the rivers through separate channels. In most towns such channels had existed from time immemorial, for it was one of the most obvious duties of the most primitive of Corporations to divert rain water from the streets and from the cellars of the inhabitants. He was therefore of the opinion that if German towns continued to increase in size as they had done during the last thirty years, it would be found, as it had been in England, that the increasing pollution of the rivers would necessitate radical changes in the magnificent works planned and executed by Mr. Lindley.

With regard to the ventilation of sewers, he also ventured to think that the author would have to modify his opinions. Mr. Hanssen was convinced that the sewers built in this country by engineers like Bazalgette, Hawksley, Mansergh and others were of the very best material and workmanship, and fully equal to anything built at the present time, either in this country or on the Continent, but it was an absolute impossibility to get brickwork consisting of two $4\frac{1}{2}$ inch rings of bricks quite watertight. The result was that all these large sewers acted as deep drains for the subsoil water, and it was even claimed as an advantage that they lowered the subsoil water. In new sewers, therefore, an abundant flow of liquid was found far above that of the sewage proper, and for some years they may keep clean and free from smell. Gradually, however, the subsoil water was lowered, the sewage became less diluted, the flow of the sewage became

more sluggish and more variable, and deposits were formed of organic matter on the invert and the sides which decomposed and gave out sewage gas, which was far more dangerous to health than German engineers would care to admit. The system of ventilation advocated by the author had been tried in England, but had been found insufficient. Air currents had a strong tendency to follow the direction of the water currents, and where soil pipes were used for ventilating public sewers there would be down-draughts during the day with strong smells from sewage gas escaping from the openings at the street level, while during the night sewage gas might rise through the soil pipe and be discharged above the roof of the houses and enter them, either through the interstices between the tiles or slates, or by passing down the chimney flues.

Mr. Hanssen believed that the only rational system of sewer ventilation was the one advocated by Mr. Isaac Shone, who proposed to use fans driven by electric motors for drawing definite quantities of air through regulated openings provided with mechanically perfect back pressure valves fixed in each house drain. In this way a current of air flowing constantly in the same direction could be maintained through each house drain, and all these small currents united in the public sewer, to produce a strong flow of air through the same. One single fan and motor was in this way able to ventilate from four to six miles of sewer at a very moderate cost, and the air and gas could be purified before it was discharged into the atmosphere by passing it through a filter containing broken coke moistened by a fine spray of water.

CORRESPONDENCE ON THE DESIGN OF A SEWER.

MR. T. D. EVANS (Member) writes:—Sewerage schemes in England are always laid down with the fact kept well in view that they are not only for present requirements, but are also for the benefit of the future population, a period of 30 years being usually estimated for. For the advantage of the present generation, deferred payments are sanctioned, so that the generation to come, who will benefit by the works, assists in paying for them.

Combined systems are certainly to be preferred, but are the most difficult to design, on account of the great fluctuation in time of storms. Where pumping is necessary, or where the sewage is treated, the amount of dilution allowed for is six times the mean flow. This allowance assists in keeping the size and cost of plant and works within a reasonable limit, and no more storm water is taken than what falls from back roofs and yards. The Local Government Board have regulations, which have to be strictly observed.

Water supply is always the basis upon which the dry weather flow is fixed, at least in England, but I must take exception to Mr. Durham's formulæ, because no hard and fast rule can be laid down. Every district in England varies much, and therefore the habits locally of the people under consideration must be studied. The maximum hourly flow may be 2½ times the mean, and eight hours maximum 1·8 times the mean. Speaking generally, English engineers design their works for one half flowing off in eight hours, plus storm water.

For the wet weather flow—a factor which in most schemes is very difficult to estimate—the rainfall statistics of the district must be tabulated, and if there is a local automatic recorder, the diagrams available of course will be extremely useful. In my experience I have found that the period of rainfall in a day is from 2 to 3 hours; occasionally there may be a drizzle lasting all day. The rate at which rain falls is the question which gives rise to the greatest difficulty in sewer design. In one district I am acquainted with the average hourly rate of rainfall is 0·049 inches per hour, equal to 1,111·6875 gallons per acre, or 2·963 cubic feet per minute per acre, and of that only 45 per cent. will at times flow off into the sewers, or at most 60 per cent.

There is not in existence any formulæ for storm water which can be universally adopted, and looking into the one the author has quoted and uses, I should be obliged if he would state how the co-efficient R can be even approximated.

There must be an error somewhere, as 1·80 cubic feet per second per acre is beyond all reason; it is equivalent to 108 cubic feet per minute per acre, and what Authority would spend the money to accommodate that quantity, plus the maximum flow of sewage? The late Mr. Crimp, when District Engineer under the London

County Council, gauged one of the London sewers, and only found 24 cubic feet per minute flowing off, which included rain and sewage. The London sewers were designed to take ¼ inch of rain per day, plus sewage, but this has been found now too little.

It should be stated that the oval is not the strongest form to adopt for sewer construction. The circular form produces much the strongest sewer, and the author does not appear to me to have given sufficient reasons for advocating other profiles. The cost of constructing an egg-shaped sewer is considerably more than that of one of circular shape, as there are three centreings in the former and only two in the latter.

I cannot understand the very low value of roughness which has been stated, as Kutter gives 0·013 for brickwork; the formula which is now used and accepted by American engineers as the best for sewers is $124\sqrt[3]{R^2}\sqrt{s}$

No sewer whatever should outfall into a non-tidal river, unless the sewage is treated either bacterially or irrigated over land. In tidal rivers a careful study of the range of tides and tidal currents must be made, otherwise difficulties may subsequently arise.

In regard to the expression, "The levels of the dry weather flow being fixed," does this refer to the sub-soil water? If not, then it would appear to have no meaning at all, because dry weather flow has no fixed value as regards level, as each hour of the day it is different, but I may have misunderstood the expression used.

I must express surprise that sewer blocks for inverts are advocated. The number of joints in the direction of flow are a serious source of trouble, and life is far too short to be spent in wholesale condemnation of materials, apart from the great expense. Neither in this country or abroad can money be thrown away. By all means get good work, but the danger of the introduction of what may after all be only extreme refinement should be guarded against.

There is no depth limits for pipe sewers, and I for one would not be afraid to, and have in fact, put pipe sewers in 50 feet below surface, and in stoneware. The means of securing it against destruction is another consideration.

The lampholes illustrated as regards concrete foundations

under top section seem to me to be of indifferent construction, and likely to fail by reason of the settlement of the made ground.

We are living in England, where Tariff Reform is strongly urged, and advocating the importation of foreign material when our own manufacturers can supply material of the quality required seems hardly desirable or necessary. England has taught the world sanitation, and the fact should be clearly declared on such an occasion as the present.

In conclusion, I desire to join in thanking Mr. Durham for the great trouble he has taken to show what is done in Germany in sewer design and construction. For members seeking such information his paper will prove exceedingly useful.

ALEX. J. SIMPSON (Member) writes:—What is the author's opinion of the construction of cast iron sewers lined with blue or other approved bricks? This system was adopted practically throughout the City of Melbourne, Victoria, when the whole of the drainage was reconstructed, and as far as I can ascertain has proved quite satisfactory. The author looks upon clay joints as ideal, but I, from practical experience, have not found this so, even for temporary work. Apart from tree roots and worms affecting them, they are easily washed out in the event of the pipes, for any reason, becoming full, and a pressure thereby being put upon the joints. He also deprecated cement joints and surrounding the pipes with concrete, but I have never yet found a drain, not so protected by concrete and placed close to the surface of the ground, sound after a heavy load such as a steam roller had passed over. I know, however, many instances where drains, well embedded in concrete, though placed close to the surface, have remained perfectly good and sound after the passage of traction engines, &c., over them.

Flexible joints may possess advantages, but if the ground sinks, the drains follow as a rule, and such sinkage causes uneven levels, and trouble soon ensues. I prefer the improved combined composition and cement joint, and the pipe well concreted round. The composition joints allow of the pipes being laid while water is passing through them, the cement joint being made when convenient afterwards. If the concrete is well packed round the whole length of the drain a form of continuous beam is made which I think is better able to resist outside movements and pressures and minimises the risk of breakage of pipes or joints due to sinking of the ground underneath.

I regard the ventilation of the sewers through rainwater pipes as a bad system. In many cases the top ends of pipes terminate close to windows, or at any rate under the eaves of the roof, and foul air can easily pass into the house. Again, the rain water pipes are not designed for vent pipes; the joints are bad and are seldom if ever made properly. The soil pipes continued above the ridge of the house as vent pipes provide the only proper means for ventilating drains.

BIRMINGHAM LOCAL SECTION.

The Eighth Meeting of the First Session was held on Friday, 15th May, 1908, at the Argyle Hotel, John Bright Street, at 8 p.m., Mr. Fred S. Pilling (Local Chairman) in the chair. There was an attendance of eight. After the minutes of the previous meeting had been read, confirmed, and signed, the Hon. Secretary read Mr. F. R. Durham's paper on "The Design of a Sewer," which was delivered at the London Meeting on the previous Tuesday.

A hearty vote of thanks to the author for his paper, proposed by Mr. G. Arblaster (Associate), and seconded by Mr. A. E. Loach (Member), was carried by acclamation. Mr. T. H. Relton (Member) said he was surprised that the angle of junction blocks was given as 60°. He had had some experience with dust exhausting pipes, and a much more acute angle had been used, but perhaps the two cases were not analogous. The author did not mention the methods used for lighting sewers. He also remarked upon the pointing mortar containing a large quantity of cement which contained about 1·1 per cent. lime. Mr. Loach stated that in the case of the lime in Portland cement, it did not exist in the free state. Mr. E. E. Jeavons had experienced the haphazard laying of sewers, in dealing with them when laying large gas mains. The importance of ventilation was very great in cases where gas mains lay in the vicinity.

Mr. R. B. A. Ellis in his observations on the paper, from his personal experience endorsed Mr. Jeavons' remarks.

The Chairman said the Local Government Board would not, in many cases, sanction sufficient money to be spent to allow for the needs of future developments. With reference to bench marks, the fixed plug was no doubt a great convenience, but considering the corrosive action of the climate, the old broad arrow had its

advantages. He mentioned the system of town planning in vogue on the Continent—by meetings of property owners. With regard to the use of the centre of streets for sewers in this country, streets were narrow, and the tramways usually occupied this position. He would be glad to know how the asphalte joint stood after 20 years, and whether it dissolved on account of its bituminous nature. Would the author consider 160 miles of sewers excessive for a town of 300,000 inhabitants? The paper was one of great benefit to the Institution, and the author must have spent a great deal of time in preparing it. Mr. Pilling made particular mention of the logarithmic charts.

He then alluded to the Durham Bursary, announced in the May *Journal*, and hoped that members of the Local Section would enter. Owing to the small number at present attached to the Local Section, it was not proposed to organise any visits to works in the district during the present summer, but where possible facilities would be arranged for members to join in the London visits.

Author's reply.

MR. F. R. DURHAM, in replying to the discussion, said he deeply appreciated the congratulations and kind words that had been expressed. He had tried to give the Institution a paper which would raise in the young engineer's mind most of the salient points to be considered in the design of sewers.

In reply to Mr. Ronald J. Francis he would state that the pointing of bricks on the Continent was done with a special tool, by means of which the joints were struck slightly hollow. If the joints of brickwork were cut too fine, the pointing became more difficult, especially in cases of re-pointing old sewers when the old joints had to be previously scraped out. With reference to strangers' galleries, his experience had been that they were largely used for inspection by engineers. For instance, at Frankfort, Mannheim, &c., he had had occasion to show the works to engineers of all nationalities.

In answer to Mr. Allen Vickers, the author said he did not understand why there should be any difficulty arising from the use of invert blocks. By means of a carefully drawn specification and insistence on accurate workmanship, satisfactory invert blocks

should be obtainable. Stoneware invert blocks were preferable to other forms of inverts: (1) because they exposed the fewest joints to the attacks of the raw sewage where it was most concentrated; (2) because the material itself was practically indestructible; and (3) for constructional reasons, as invert blocks formed a good seating for starting the brickwork of the sides of the sewers. The author remembered seeing some invert blocks taken up after over thirty years of use which showed no signs of wear at all, and were immediately used again on a new section of sewer.

He endorsed the remarks of Mr. R. S. Lindley in every respect.

Replying to Mr. Waldram, he remarked that the difficulty of pipes being temporarily too large could be overcome by proper flushing arrangements, which would prove considerably cheaper than relaying the sewer at a later date. He had worked with such arrangements for flushing sewers as described by Mr. Waldram, using however a leather cone-shaped bag instead of balls. In answer to Mr. Waldram's question as regards junctions on pipe sewers, the usual practise on the Continent was to provide them for future connections, in order to keep the sewer intact after it had once been laid. He had never heard of any disadvantages arising from this practise. In cases where the house connections were to be made almost immediately on the completion of the sewer itself, it was customary for some town authorities to carry out a portion of the house drainage itself between the axis of the sewer and the edge of the pavement at the expense of the house owner. As regards his remarks on ventilation as well as those of the other members who took part in the discussion, the author was perfectly convinced from his own practical experience that the free circulation of air as described in his paper was the correct one in a properly designed system of sewers. He did not wish to assert that it would be advisable in unsystematic networks of old sewers where the sewer men were exposed to noxious gases. There ought to be no sewer gas at all, as the sewage should be carried off before putrefaction took place. The through circulation rendered unnecessary all such complicated machinery as advocated by Mr. Hannsen. The suggested difficulties of the pollution of the air under roofs or near attic windows were easily overcome by byelaw regulations fixing the distance from the objects in question at which such vents might be placed.

In reply to Mr. Reginald Marshall the author objected to the use of concrete for sewers, on the ground that sewage gradually disintegrated the concrete. He was confirmed in his conviction by the fact that the more important manufacturers of concrete sewer profiles listed various materials, such as stoneware, asphalt compositions, &c., to protect the concrete.

The author appreciated Mr. Hannsen's remarks on a separate system, and was a firm believer in treating each case on its individual merit, but it must always be remembered that the separate system entailed two networks of sewers and two systems of house drainage for every individual house. As he pointed out in his paper the whole question was one of careful financial calculation. He did not agree with Mr. Hannsen's observations on subsoil water, as they were contrary to the results obtained.

In reply to Mr. Evans, the author had taken particular care not to lay down any hard and fast rules, and therefore the remarks as to the formula given in the paper did not hold good. He would have preferred to see that Mr. Evans did not work to $\frac{1}{1000}$ and $\frac{1}{10000}$ of a gallon and cubic feet per minute per acre, as such accuracy did not exist in hydraulic formulas. With reference to the formula for storm water, he was pleased to see that his figure of 1·80 cubic feet per second per acre = 108 cubic feet per minute per acre, compared favourably with the measurements of the late Mr. Crimp. The error was on the part of Mr. Evans, as he had forgotten that the formula given for the storm water bore with it a fourth root with a limitation, that never less than $\frac{1}{4}$ of the accepted value should be taken for instance in this case $\frac{108}{4} = 27$ cubic feet per minute.

The author was sorry that Mr. Evans had apparently misunderstood the question of the fixing of the levels of the dry weather flow. The calculation of such levels would give the mean level of the dry weather flow, which would determine the depth of the sewer below ground, and would insure a properly distributed velocity throughout the network. The author believed that if his statements in the paper were carefully studied they would be found correct. He did not understand Mr. Evans' criticism in regard to invert blocks, as they reduced, and did not increase, the

number of joints, nor could he understand the remark that "life is far too short to be spent in wholesale condemnation of materials," when the whole object of hygiene was to increase the life of mankind.

He also thought that Mr. Evans' observations on the depth limits for pipe sewers were unwise. Mr. Evans seemed to forget that the repairs and inspection of a pipe sewer laid at a depth of 50 feet (which the author presumed would have to be done in tunnel) were practically impossible. It was therefore far wiser, and no more expensive, to carry out such lengths of sewer in the form of a brick profile, which could be inspected at all times.

In reply to Mr. Simpson he referred him to that part of the paper dealing with jointing, where it would be found that the clay joint was only described as ideal from the point of view of flexibility. The author had seen on several occasions pipes embedded on concrete severely cracked across, and the sewage polluting the surrounding ground. The flexibility of a long pipe line was absolutely essential, and he would refer to the method of jointing cast-iron pipes with lead and gasket in order to insure their flexibility. As regards the life of the asphalt joint the author is not aware of any defects having arisen. There are sewers now 20 years old which have not shown any signs of failure.

He thanked the members of the Birmingham local section for their kind remarks, and in reply to Mr. Relton's question about the angle of junction, would say that the angle of 60° not only possessed the advantage of giving a flow of least disturbance, but also a greater convenience in constructional work, for a standardised angle of 60° reduced immediately the enormous number of special pipes required for sewer and house drainage purposes. He wished to say in reply to Mr. Pilling that the question of corrosive action of the climate on cast-iron plugs for bench marks need not be entertained, as such plugs had been used for years in those parts of the Continent which had a similar climate to our own. With further reference to bench marks, the author would only like to add that he had not yet succeeded in finding out whether the top edge, the middle, or the bottom edge of the broad arrow was the correct level, and what was the most usual satisfactory means devised for insuring that the staff man held the staff in the correct position. In the case of cast iron plugs there could be no doubt.

WATER CURTAIN AND DRENCHER SYSTEMS OF FIRE EXTINCTION.

The Fifteenth Visit of the Twenty-seventh Session took place on Saturday afternoon, 11th April, 1908, for witnessing, by invitation of Messrs. Mather and Platt, demonstrations with the Water Curtain and Drencher Fire Extinguishing Apparatus they had installed at the premises of Messrs. Foster, Porter and Co., 47 Wood Street, City, and at those of the Maypole Dairy Company, 27-53 Leonard Street, City Road, the following particulars of which have been kindly furnished by Messrs. Mather and Platt. The attendance was 23.

At the conclusion, Mr. George T. Bullock (Vice-Chairman) expressed the thanks of the Institution for the opportunity which had been given the members of seeing such interesting displays of these special fire extinguishing plants, and Mr. J. W. Spiller replied on behalf of Messrs. Mather and Platt.

The Drencher installation at the premises of Messrs. Foster, Porter and Co. protects all faces of windows, roofs, and skylights. There are in all 282 drencher heads, divided into five sections. Water can be turned into any desired section by opening the valve controlling that section. The controlling valves are grouped together in a window on the ground floor of the Wood Street face of the building, where they are easily accessible from the inside, and also from the outside in case of necessity.

The water supply to the system consists of a No. 3 size Ellington's automatic injector apparatus capable of delivering 650 gallons per minute. This injector is supplied by a 6-inch branch from the 9-inch district main in Wood Street, coupled direct on to the suction end of the apparatus. The pressure in this district main is 30 lbs. per square inch at ground level. The standing pressure maintained on the delivery to the drenchers is 85 lbs. per square inch. The hydraulic supply is a 3-inch branch from the Hydraulic Power Company's main.

In addition to the injector apparatus, suitable provision is made to enable the engines of the London Fire Brigade to pump direct into the system. At the demonstration witnessed by the members, two of the London Fire Brigade's engines, each having a nominal

capacity of 450 gallons per minute, were coupled up, and the drenchers on two sections (Wood Street and Addle Street) were well supplied with water. Subsequent trials with the injector as the means of supply not only gave good distribution of water from these two sections, but in addition a third section at the back of the premises, viz., Philip Lane, was well supplied, and there was little doubt that the injector would have fed the remaining sections, but for fear of flooding the streets and cellars it was not deemed advisable to test all the drenchers at one and the same time, drencher protection being to prevent fire in the adjoining premises spreading to the protected building. It is obvious that unless a building were surrounded by burning premises the whole of the drenchers on all the exposures would not be required to operate at one and the same time.

At the demonstration carried out at the premises of the Maypole Dairy Company only one fire engine was at work and there are here only three sections. The total number of drenchers is 111. The arrangement of valves and water supplies is very similar to that at Messrs. Foster, Porter and Co.'s premises, but it is only necessary that the injector apparatus should be capable of delivering 500 gallons of water per minute.

STORM RELIEF SEWER WORKS.

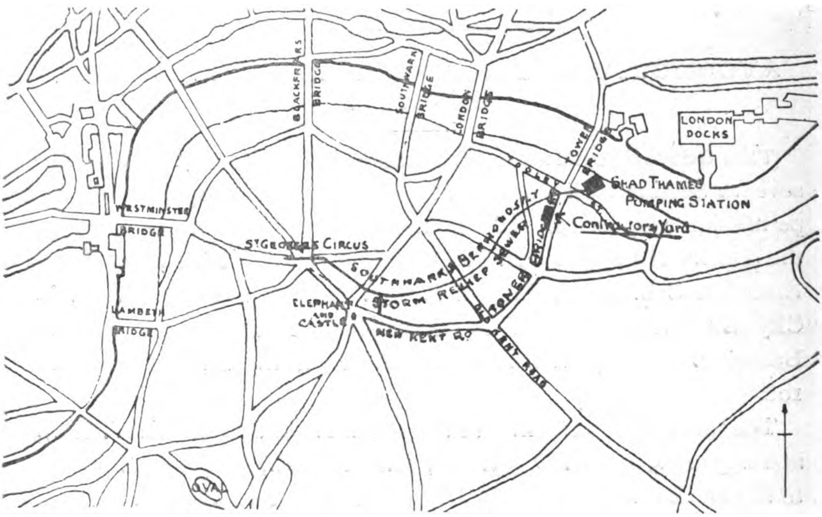
The Sixteenth Visit of the Twenty-seventh Session took place on Saturday afternoon, 16th May, 1908, when, by permission of Mr. Maurice Fitzmaurice, C.M.G., M.Inst.C.E., Chief Engineer to the London County Council, the Southwark and Bermondsey Storm Relief Sewer Works were inspected, under the guidance of the Resident Engineer, Mr. John P. Harris, M.Inst.C.E., and Mr. F. P. Hughes (Member of the Institution) representing the Contractors, Messrs. The Tilbury Contracting and Dredging Company.

Assembling at 3 p.m. in the contractors' yard in Tower Bridge Road, the party, 36 in number, after being shown the drawings of the work, descended to the sewer where the mode of construction

adopted, method of putting in the concrete lining, and other details were explained. After seeing the air-compressing plant, &c., on the surface, they proceeded to the Pumping Station at Shad Thames, the building of which had been completed, and a commencement made on laying down the plant.

At the conclusion, on the proposal of Mr. George T. Bullock (Vice-Chairman), seconded by Mr. J. W. Nisbet (Member of Council), a cordial vote of thanks was passed for all that had been done to render the visit so interesting, Mr. Harris replying.

The following notes and sketch map have been kindly furnished by Mr. Fitzmaurice.



In times of storms and heavy rainfall the existing sewers in the districts of Southwark and Bermondsey are surcharged to such an extent that frequent floodings of cellars and basements occur. The Southwark and Bermondsey storm relief sewer is, therefore, being constructed in order to remedy this trouble. The storm sewer, which is about 1½ miles in length, commences at St. George's Circus, Southwark, and terminates at Shad Thames, Bermondsey. It commences with 5 feet diameter brick barrel and increases to 7 feet, and eventually to 8 feet diameter cast iron tunnels lined with concrete. At intervals, connections are made with the existing sewers, in which weirs are formed at such a level, that although in times of normal flow no sewage leaps the weir, in times of storm

when an excess amount of water has to be dealt with, it will flow over the weirs and into the storm sewer. The brick portion of the sewer was built in "cut and cover," and the cast iron portion in tunnel by means of a shield and with the aid of compressed air through water bearing ballast. At the termination of the storm sewer at Shad Thames, a pumping station is in course of construction. Three 30-inch diameter centrifugal pumps are provided, each capable of raising one million gallons per hour, when running at a speed of 180 revolutions per minute. The pumps will be driven by gas engines and will discharge the storm water through culverts into the river, below low water level.

AVONMOUTH DOCKS, AND ELECTRICITY WORKS, BRISTOL.

The Seventeenth and Eighteenth Visits of the Twenty-seventh Session took place on Saturday, 23rd May, 1908, when, by permission respectively of the Bristol Docks Committee, through the Docks Engineer, Mr. W. W. Squire, M.Inst.C.E., and of the Electrical Committee, through Mr. H. Faraday Proctor, M.I.E.E., City Electrical Engineer, the Avonmouth Docks Works and the Bristol Electricity Works were inspected, the attendance being 108.

The members were met at Stapleton Road Station (G.W. Ry.), at 10.45 a.m., by Mr. Don Swan, M.I.Mech.E., Resident Engineer to the Docks Committee (Institution Member of Council for the West of England). As many as possible of the party were taken by steam tug, kindly provided by the Committee, down the Avon (passing under the Clifton Suspension Bridge) to Avonmouth, while the remainder proceeded by train. On re-assembling at the Docks Works, Mr. Frederick Colson, representing the Contractors, Messrs. John Aird and Co., met the party.

Some of the constructional work which was in progress having been inspected, luncheon, on the kind invitation of the Contractors, was partaken of in one of the dock sheds, specially fitted up and decorated for the occasion. Mr. Colson occupied the chair. Several appropriate toasts were cordially pledged, "The Port of Bristol" being proposed by Mr. George T. Bullock (Vice-Chairman

of the Institution), and responded to by Mr. Don Swan; that of "Messrs. John Aird and Co." was proposed by the Chairman of the Institution (Mr. F. R. Durham), and responded to by Mr. Colson. Telegrams of thanks, and congratulation on the approaching completion of the undertaking were despatched to Sir John Aird, Bart. (Vice-President of the Institution), and to his son, Mr. Malcolm Aird (Hon. Member).

In the afternoon other parts of the Works were seen, and the ferro-concrete transit shed, warehouse, &c., inspected. Mr. Don Swan then kindly entertained the members to tea. Their appreciation of his hospitality, and of the interest he had taken in all the arrangements for the visit, which had proved so interesting and enjoyable, was expressed by Mr. Durham.

The party then returned by train from Avonmouth to Clifton Downs Station, proceeding thence by special tram cars to Avonbank for the visit to the Electricity Works, over which they were shown by the Deputy Engineer and his assistants. Before dispersing. the members passed a cordial vote of thanks for the various facilities which had been arranged for their benefit in connection with the inspection of these works.

For the following particulars the Institution is indebted to the respective proprietors:—

AVONMOUTH DOCKS WORKS.

The Avonmouth Docks, the property of the Bristol Corporation, are situated at the head of the Bristol Channel. The large basin of the Royal Edward Dock, now approaching completion, is 1,000 feet wide, and the mean length from north to south 1,120 feet. At the south-eastern corner there is a branch about 500 feet long and 250 feet wide, from the end of which a passage 85 feet wide communicates with the old dock. At the north end of the dock provision has been made for constructing two more branches, each 1,800 feet long, 300 feet wide, to provide additional accommodation in the future.

The dock is entered from Kingroad through a lock 875 feet long, 100 feet wide, situated near the south-western angle of the dock. The outer sill has a depth of 36 feet of water at ordinary neap tides, and 46 feet at ordinary spring tides. The lock is closed by

three pairs of gates of which the inner pair is erected, and the other two pairs are in course of erection. The caisson for the graving dock has been erected. At the outer end of the lock there are two piers, 900 and 1,200 feet long, respectively, and there is a lighthouse (constructed of granite) on each of the two pier-heads. On the northern side of the lock, and running parallel to it is a dry dock 850 feet in length, with entrance 100 feet wide, which is entered from the Royal Edward Dock. The Junction cut is closed by a caisson and crossed by a swing bridge, both of which are completed.

The pump chambers and pumping engine, and boiler houses for the dry dock are nearly completed, and the large pumping engines for emptying the dry dock are in course of erection. The machinery in connection with the sluices for regulating the level of the water in the old and new docks, in the lock and graving dock; the machinery for opening and closing the gates, and for working the chain booms which protect the gates from injury, have all been delivered, and the greater part has been erected. The capstans have been delivered and erected.

On the eastern side of the dock two transit sheds, each 500 feet in length, and two stories high, are in course of erection, and on the southern side a transit shed 450 feet in length, consisting of a single floor only, is completed (ferro-concrete). Behind the sheds, on the eastern side of the dock, a large granary is being erected, capable of containing 50,000 quarters of grain, the greater portion of the grain being stored in bins and the remainder on floors. Between the dock and the sheds on the eastern side there is an underground passage leading to the granary, and this passage will contain a number of conveyor belts for conveying grain from the vessels discharging at the sheds to the granary, where it will be automatically weighed before being lifted by means of elevators to the top floor, and distributed by other conveyors to the different bins and floors where it is intended to be stored. Pneumatic elevators will be provided to lift grain from the hold of the vessel and deposit it on to the bands or into craft or trucks alongside. There will be other conveyors from the granary to the dock side, for the purpose of reloading grain into craft. The construction of the grain conveying and elevating machinery is proceeding.

Each of the double-storied sheds will be provided with six cranes, capable of lifting 1½ ton each. Opposite the shed, at the export berth on the south side, there will be two cranes capable of lifting 10 tons each, two 3 tons each, and one 1½ ton.

The dock will be completely surrounded by lines of rails connected with the railways on the old dock and with the Great Western and Midland Railway Companies' systems. On the north-eastern side of the Dock Estate there is under construction a large railway yard, containing several nests of sidings for the interchange of traffic between the Railway Companies and the Dock, and for sorting and marshalling railway traffic. By the new railway connection to Filton now being laid down by the Great Western Railway Company shortening the distance between Avonmouth and London by fourteen miles, passengers can be in London within two hours of their disembarking at the passenger station at the pier.

AVONBANK ELECTRICITY WORKS.

The Avonbank Electricity Works are situated at St. Phillips Marsh, the site being 11 acres in extent. The Town Council having obtained the Local Government Board Provisional Order in 1883, Bristol was one of the first municipalities to obtain powers. The original station was at Temple Back. The first portion of the works at Avonbank was opened in 1902, and in the following year the second, inaugurating a three-phase supply, was put in hand. In 1904 a further equipment, including turbo-generators, was installed. The total plant capacity is now 12,890 k.w., made up as follows:—

Eighteen Babcock and Wilcox water tube boilers, having an evaporation capacity varying from 15,000 lbs. to 35,000 lbs. of water per hour; two 750 k.w. Willans' central valve engines, coupled to two Siemens' alternators, 2,000 volts single-phase; three 750 k.w. Parsons' steam turbines coupled to three Parsons' alternators, 2,000 volts, single-phase; a 600 k.w. Parsons' steam turbine, coupled to Siemens' alternator, 2,000 volts, single-phase; two 1,000 k.w. Willans' turbines, coupled to two three-phase Dick-Kerr alternators, 6,000 volts; a 3,000 k.w. Westinghouse turbine, coupled to one three-phase Westinghouse alternator, 6,000 volts; a 3,000 k.w. Westinghouse turbine, coupled to one single-phase

Westinghouse alternator, 2,000 volts; a 210 k.w. Willans' central valve engine, coupled to one Dick-Kerr D.C. generator, 500 volts, D.C.; two 165 k.w. Willans' central valve engines coupled to two Siemens' D.C. generators, 500 volts, D.C.

There are two overhead electric travelling cranes, of 15 and 30 tons respectively.

The total capital expenditure of the Bristol undertaking to date is approximately £720,000. The number of consumers connected is 3,106, having installations equivalent to a total of 365,000 30-watt lamps.

Mains are at the present time being laid to Avonmouth, a distance of about eight miles, for the purpose of supplying the docks, and for power and lighting in the neighbourhood. The area covered by the system is one of the largest in the kingdom—there are in all about 350 miles of mains laid, and about 90 sub-stations, the most important being those at Temple Back, Underfall Yard, and in the near future, that at Avonmouth.

TO MEMBERS IN THE COLONIES AND ABROAD.

In the next issue of *The Journal* it is intended to publish several communications which have been received from Members in the Colonies and other parts of the world.

Those who have not yet responded to the request for some news of their doings are assured that letters from them will be appreciated.

SUMMER MEETING IN FRANCE.

The Twentieth to Thirty-seventh Visits of the Twenty-seventh Session took place during the Institution's Summer Meeting in France from Saturday, 27th June, to Saturday, 11th July, 1908, the total attendance being 40. The programme was arranged as follows :—

Saturday, 27th June.

Arrival in Paris. (Grand Hotel.)

Monday, 29th June.

The Conservatoire National des Arts et Métiers, Rue St. Martin, Paris.

The de Dion Bouton Automobile Works, 36 Quai National, Puteaux.

Reception at the Institution of Civil Engineers of France, 19 Rue Blanche, Paris, by invitation of the President (M. E. Reumaux) and Council.

Tuesday, 30th June.

Special steamer excursion on the Seine for visit to the Nanterre Works of the Compagnie l'Union des Gaz; and inspection of 880,000 cubic feet gasholder under course of construction by Messrs. Samuel Cutler and Sons.

Wednesday, 1st July.

Morning left free for visiting places of popular interest in Paris, train being taken at 2.25 p.m. for Le Creusot. (Nouvel Hotel Moderne.)

Thursday, 2nd July, Le Creusot.

The Works of Messrs. Schneider and Co. at Le Creusot. [For the ladies of the party a special programme, including a vlsit to Versailles, was arranged.]

Friday, 3rd Jnly.

Morning left free for visiting places of popular interest in Paris.

Afternoon—visit M. Say's Sugar Refinery, 123 Boulevard de la Gare.

Evening—Institution's Summer Dinner at the Grand Hotel, Paris.

Saturday, 4th July.

Drive for visit to the Chamber of Deputies, including an inspection of the Saloons, Library, Chamber, &c.; the Palais de Justice; the Hotel de Ville, the Hotel des Invalides, &c.

Evening—Dinner at the Pré Catelan, Bois de Boulogne, by invitation of the President (M. Gustave Canet) and Madame Canet.

Monday, 6th July.

Inspection of Flying Machines and Demonstrations by MM. Bleriot and Farman, at Issy les Moulineaux.

The Cartridge Manufactory of the Société pour la Fabrication des Munitions d'Artillerie, 71 Quai d'Issy les Moulineaux.

The Electric Generating Station of the Chemin de fer Ouest (Usine Electrique des Moulineaux) at les Moulineaux.

Tuesday, 7th July.

The Lifts and Machinery, &c., of the Eiffel Tower, and ascent to base of flagstaff at summit.

The Works of the Metropolitain, under the Boulevard St. Germain.

Wednesday, 8th July.

Morning left free for visiting places of popular interest in Paris.

Afternoon—The St. Denis Electric Generating Station of the Société d'Electricite de Paris.

Thursday, 9th July.

Morning left free for visiting places of popular interest in Paris, train being taken at 1.20 p.m. for Le Havre. (Hotel Continental.)

Friday, 10th July, Le Havre.

Docks and Depôts at Le Havre.

Works of the Société des Forges et Chantiers de la Mediterranée.

Harbour Works.

Electric Lighthouse.

Saturday, 11th July, Rouen.

In the morning members left Le Havre for Rouen, the Cathedral and other special features of architectural interest there being seen.

In the much regretted absence of the President, M. Gustave Canet, owing to illness, the members, on their arrival at Paris, were met by his sons, MM. Paul and Albert, who throughout the whole period of the meeting were most genial and indefatigable in doing everything they possibly could to enhance the interest and enjoyment of the occasion, while the presence of Madame Paul Canet and of Madame Albert Canet from time to time lent an added charm to the proceedings.

By the kindness of the President and Council of the Institution of Civil Engineers of France, their house at 19 Rue Blanche, containing reading and writing rooms, library, &c., was open for the use of the members during their visit to Paris.

Permission for the visit to the Conservatoire National des Arts et Métiers had been specially given by the Minister of Commerce and Industry, and the party were conducted over by M. J. Eloy. The cases containing the celebrated musical automata were opened and the figures operated. In the testing department several of the Engineers attended to point out the features of interest and to explain the nature of the work undertaken.

After luncheon at the Taverne Pschorr, Boulevard de Strasbourg, the party were, by the kindness of the De Dion Bouton Company, conveyed to Puteaux to visit their Automobile Works. The Marquis de Dion and M. Gaston Bouton greeted the visitors on their arrival, and, divided into groups, they were shown through the different departments and subsequently returned to Paris by the route taken in going.

At the reception in the evening the party on assembling in the handsome lecture hall of the Institution of Civil Engineers of France were cordially addressed in French by the President, M. E. Reumaux, his speech being afterwards repeated as follows :—

"Ladies, Mr. Chairman, Gentlemen,

" I apologise for speaking to you in French, and am, I confess, a little ashamed not to be able to welcome you in your own tongue. Many a man of my generation has deeply regretted, in the course of his existence, his ignorance of the language of so many learned men, of so many first-rate engineers, and that is why they no longer fail to base the education of their own children on a knowledge of English, more especially of those children destined to be engineers.

" We have been greatly flattered to see the name of the Society of Civil Engineers of France placed at the head of the programme of your " Summer Meeting," and we are happy to tell you that you are doubly at home here, on the one hand as engineers, and on the other as members of an Association presided over by our former President of the Society of Civil Engineers of France, M. G. Canet.

" It is with particular pleasure that we welcome you in Paris; it is indeed rare in the histories of technical societies, to see them elect as President a stranger, and the choice which you have made this year of one of my eminent predecessors at the Society of Civil

Engineers of France has a special significance if one remembers the nature of M. Canet's creations, the artillery material, of which he is the author, and which is so well known and so highly appreciated.

"Gentlemen, you have thus given a most striking example of that spontaneous and active confidence which characterises the young and does them honour, and it is to be desired that this example may be followed by others to the greatest advantage of our relations on either side of the channel, and of the progress of science in general.

"The pleasure of receiving you would have been greatly enhanced, had we not to deplore the absence of M. Canet, kept away from us by illness. He would have been so proud to introduce you into this house, to present you to his colleagues of the Civil Engineers, he would have told us how highly he values this title of President of the Junior Engineers, in which he succeeds so many illustrious Britons, such as Lowthian Bell, S. Thompson, and White.

"In his absence you will be brilliantly led by your Chairman, Mr. F. R. Durham, whose reputation as hydraulic engineer has crossed the channel, and whose works in Germany with Mr. Lindley, and more recently in England, are so well known and appreciated. Under his able guidance, this journey will without doubt be most profitable and most interesting.

"You will be confronted many times by methods, processes and installations, differing essentially from what you are accustomed to see at home. Do not be hasty to sum up in favour of one or the other systems; study the installations in their relations with local conditions and you will recognise, I venture to think, the ingeniousness of the solutions adopted to meet the special exigencies of an individual case.

"These frequent examples of our specialising in the way of works may be advantageously applied to the more general solutions largely in use in England. Both systems have their advantages, and it will be entirely in your interests in practice to take inspiration from both.

"During your stay in Paris, this house will be your own, and we invite you to make the widest use of our library, our reading, writing and reception rooms.

"Gentlemen, I would ask you to express to your President Canet our regret at his absence and our sincerest wishes for his speedy and complete recovery. I drink prosperity to the Society of Junior Engineers and to the health of its Chairman, Mr. F. R. Durham."

Mr. Durham then replied in French, the translation of his speech being as follows:—

"Mr. President, Ladies, and Gentlemen,

"I must first of all express our heartfelt regret that our dear President, M. Canet, is not amongst us to-night. Unfortunately, his absence is due to illness, and I am convinced that we all agree in wishing him a speedy recovery, and in assuring him and Madame Canet of our respectful sympathy.

"If he had been here this evening, he would doubtless have expressed our thanks to the Société des Ingénieurs Civils de France in far more eloquent terms than I am able to. He has written to me that he would have been deeply touched, himself a former President of the Civil Engineers of France, to be received by them as President of the Junior Institution of Engineers; for he has often assured us that this honour of the Presidency, which is the highest the Institution can confer, has been one of those nearest his heart in his long career of Civil Engineer.

"The admiration which we have for our President has been crowned by his acceptance of the honour which we wished to confer on him, by his appreciation of our efforts and aims, by his generosity and his hospitality. He immediately entered into the spirit of our Institution, whose object is the advantage and the co-operation of young Engineers, enabling them to meet, to discuss among themselves and with those who have acquired experience, the difficulties which they encounter in their profession, to acquire assurance, and to help one another.

"Our Institution is proud of the distinction of its President and has been congratulated on all sides on the courage of its choice. For there are many scientific societies, that have conferred their orders of merit on men of genius in foreign lands, but we flatter ourselves that we have been the first to carry international friendship to such a point as to place professional eminence, above national prejudices. We hope by this means to have tied still

tighter the bonds of friendship established between our two great nations, and the spirit of which is spreading over all the civilised countries of the world.

"Gentlemen, we have come here to see some of the great works of your country, we have come to learn and to form, we hope, bonds of friendship of our own. We are deeply touched by our reception this evening, which is for us one of the most important events of our visit, for it proves once more that science is ever ready to receive with open arms those who are striving to solve the problems which she still keeps back.

"I have thus, as Chairman of the Junior Institution of Engineers, to express to you in the name of our dear President, and in that of the Junior Institution of Engineers, my heartiest and most sincere thanks for the cordial words in which you very kindly bid us welcome and for the delightful manner in which you have offered us the hospitality of your superb house."

The President and other members of the French Institution then escorted their guests over the building to view the Council and Committee Rooms, Library, Reading and Writing rooms, &c. Refreshments were offered in the lecture hall, and the rest of the time was agreeably passed in conversation.

A most enjoyable day was spent on Tuesday, 30th June. By special steamer, kindly provided by Messrs. Samuel Cutler and Sons, the party were taken down the Seine to Nanterre, passing Issy les Moulineaux, Billancourt, Boulogne, Meudon, Sevres, St. Cloud, Suresnes, Neuilly, Puteaux, Courbevoie, Levallois, Perret, Clichy, St. Ouen, Asnières, Gennevilliers, St. Denis, Epinay, Argenteuil, Colombes, and Bezons. After refreshments, by the kind invitation of the Compagnie l'Union des Gaz, their works were visited, and the gasholder being constructed for them by Messrs. Cutler was inspected, under the guidance of M. Charpentier and Mr. Samuel Cutler, Jun. (Past Chairman of the Institution).

The party were hospitably entertained on board as the steamer returned to Paris in the afternoon, and acknowledgements of all that had been done for their interest and enjoyment throughout the day were expressed by the Chairman.

The visit to Messrs. Schneider's colossal works at Le Creusot, by the special invitation of M. Eugéne Schneider, was perhaps the

Diameters.

Tank	...	...	120 ft. 0 ins.
Outer Lift	...	...	117 „ 6 „
Second Lift	...	...	115 „ 0 „
Inner Lift	...	...	112 „ 6 „

Weights.		*Tons.*
Metal in Tank ...	...	346
„ Gasholder	...	260
„ Guide-framing	...	147
Water in Tank ...	...	9,720
Weight on Foundation	...	10,473

Water in Tank ... 2,174,800 gallons.

Number of 1 in.	diameter	rivets		...	6,500
„ $\frac{7}{8}$	„	„	„	...	17,500
„ $\frac{3}{4}$	„	„	„	...	70,500
„ $\frac{5}{8}$	„	„	„	...	18,300
„ $\frac{3}{8}$	„	„	„	...	30,300
„ $\frac{5}{16}$	„	„	„	...	116,000
					259,100

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most notable of the meeting. Nothing could have exceeded the warmth of the welcome which was extended. Carriages were kindly provided for the use of the members on their arrival at Le Creusot on Wednesday night, and throughout Thursday; special processes were timed so that they could be seen in operation as soon as the party reached the respective plants, and the heads of each department ably acted as conductors.

The morning was spent in the rolling mill and armour-plate departments, followed by luncheon in the Works Club House, at which M. Rais presided in the unavoidable absence of M. Schneider. Several appropriate toasts were pledged, and afterwards hosts and guests grouped together for a photograph commemorative of the occasion to be taken in the private park of the Chateau de la Verrerie, M. Schneider's residence when at Le Creusot.

After walking through these beautifully wooded grounds the carriages were again requisitioned for driving first to the ordnance department and then on to the construction department, finishing with the steel works and the blast furnaces.

The party left Le Creusot at 10.17 p.m. for Paris, arriving at 6.5 in the morning.

The visit to M. Say's Sugar Refinery on Friday afternoon, 3rd July, by permission of M. Peytel, President of the Board of Direction, took place under the guidance of M. Alfred Letort and M. Maurice Tinardon and proved exceptionally interesting.

In the evening the Chairman, Mr. Frank R. Durham, Assoc. M.Inst.C.E., presiding, the Institution's Summer Dinner was held at the Grand Hotel, Paris, a number of distinguished French engineers and others having been invited. The list of toasts was as follows:—"The King, and the President of the French Republic," proposed by the Chairman; "The Ladies," proposed by Mr. R. H. Parsons, Assoc.M.Inst.C.E. (*Member of Council*), acknowledged by Mr. A. C. Beal; "The President of the Junior Institution of Engineers," proposed by the Chairman, responded to by M. Paul Canet (*Membre de la Société des Ingénieurs Civils de France*); "La Société des Ingénieurs Civils de France," proposed by Mr. W. J. Tennant, M.I.Mech E. (*Past Chairman*), acknowledged by M. Charles de Fréminville (*President de la deuxieume section de la Société*) and "French Industries," proposed by Mr. Percival Marshall,

A.I.Mech.E. (*Past Chairman*), responded to by M. Maurice Tinardon (*Ingénieur des Ponts et Chaussées, Administrateur Delegué de la Société des Raffinerie d' Sucrerie Say*).

With the assistance of M. Albert Canet the party were enabled to enjoy the privilege of seeing the interior of the Chamber of Deputies on the following morning; the Hotel de Ville and other buildings of public interest were also specially visited.

In the evening, by the kind invitation of the President and Madame Canet, a Dinner in honour of the Institution was given at the Pré Catelan Restaurant in the Bois de Boulogne. M. Paul Canet presided, and amongst the guests were included several eminent Past-Presidents of the French Institution of Civil Engineers. A few sincere and well-chosen words expressing appreciation of the kindness of the host and hostess of the evening, whose absence all deeply regretted, and of the pleasure which the members of each Institution had derived from meeting one another, formed the theme of two or three speeches which followed, and, at the desire of MM. Paul and Albert Canet, English songs and music occupied the remainder of the evening.

Count de la Vaulx, Honorary Member of the Institution, Vice-President of the Aero Club de France, in fulfilment of his promise to do so if possible, kindly made arrangements for some aeroplane experiments to be carried out on Monday, 6th July, at the Parc d'Aviation at Issy les Moulineaux, so that the members might witness them during their visit to Paris.

In the morning the aeroplanes of M. Bleriot and of Mr. Henry Farman were seen at close quarters but the wind being unfavourable no flight was attempted. After luncheon, however, weather conditions having improved, M. Bleriot ascended and remained in the air for over three minutes, his fine performance being followed with the closest attention by the members who heartily congratulated him upon it. They had then to leave for the visit to the Cartridge Manufactory and so did not witness his second flight of 8 minutes 22 seconds in duration, which took place at about 6 o'clock. It should be added that in the evening at about 7.40 Mr. Farman set his aeroplane in motion and at an average height of ten feet made a flight occupying over twenty minutes, thereby winning the

Armengaud prize of £400, which was offered to the first aviator who should remain in the air for a full period of fifteen minutes in a heavier than air machine.

The fine equipment of hydraulic and other machinery, &c., which was seen at the works of the Société pour la Fabrication des Munitions d'Artillerie, carrying out all the processes involved in the manufacture of cartridge cases, presented numerous points of technical interest which were fully indicated to the members by the officials who acted as guides; and the original programme for the day was extended by a visit to the power house of the Chemin de fer Ouest close by, containing nine Westinghouse generators of 800 k.w. each.

At the Eiffel Tower on the following morning M. Gustave Eiffel, its designer and engineer, received the members, and after showing them the hydraulic machinery in the base for working the lifts, &c., accompanied them to his room at the top of the Tower. Here copies of the drawings and photographs of the work when under construction were examined and the invitation accepted for ascending thence to the base of the flagstaff on the summit, the highest point it was possible to reach. The visitors' book having been signed, M. Eiffel expressed the pleasure he felt in receiving the visit of the Institution, and concluded by drinking to its continued prosperity. Mr. Durham made a suitable acknowledgment on behalf of the members and, on his proposal, the health of M. Eiffel was pledged with musical honours. The party then descended to the first platform where, subsequently, luncheon was served, M. Eiffel being present. Some charming souvenirs of the visit were distributed amongst the ladies by him, and speeches were made, during which M. Eiffel was very cordially thanked for the honour he had conferred on the Institution by personally receiving the party.

During the inspection in the afternoon of the works of the Metropolitain, under the Boulevard St. Germain, by permission of M. F. Bienvenüe, Inspecteur Général des Ponts et Chaussées, Chef du Service Technique du Metropolitain, the members had the advantage of the presence of the Engineer-in-Chief, M. Locherer, who explained in the fullest manner the many features of engineering interest which were to be observed, and the nature of the

difficulties which were being met with and successfully overcome. A number of drawings and illustrations of the work were shown in this connection.

At the recently erected St. Denis Electric Generating Station which, by the courtesy of the Société d' Electricite de Paris, was included in the programme for Wednesday afternoon, 8th July, M. Schonne and M. Saint Denis acted as guides. Many features of great interest were noticed in the coal unloading and conveying plant on the wharf and in the store, the Babcock and Wilcox boiler installation, the Parsons' steam turbine sets made by Brown, Boveri and Co., and in the numerous details of the station.

Through the goodness of Messrs. Schneider and Co., their representative, M. le Comte Raoul de Villette, met the party on their arrival at Le Havre on Thursday evening, 9th July, and conducted them throughout the visits arranged for the following day. These opened with an inspection of the Docks and famous Coffee Depôts, under the guidance of M. Corbon and other officials. The members then proceeded to the works of the Société des Forges et Chantiers de la Mediterranée through which they were directed by M. Cody and his colleagues. In the afternoon the Harbour Works which are being carried out at Le Havre were seen, the Engineer, M. John Collet, and the Contractor, M. Joseph Digner, attending to explain the objects and methods adopted in the execution of this important undertaking.

At the conclusion of each visit during the meeting the thanks of the Institution, for the courtesies which had been extended in so friendly a manner, were conveyed by Mr. Durham, whose exercise of the French language, conjointly with Mrs. Durham, and that of Mr. Percival Marshall and of others, proved of great assistance from day to day. Presentations in token of the members' appreciation of the exertions of the Chairman and Secretary in organising and carrying through all the arrangements for the meeting were made to Mr. Durham and Mr. Dunn at Le Havre during the concluding portion of the programme.

The Junior Institution of Engineers.

WORKS' NOTES OF SUMMER MEETING IN FRANCE.*

27th June to 11th July, 1908.

CONSERVATOIRE NATIONAL DES ARTS ET METIÈRS.

GROUND FLOOR.

Room 1 (Entrance Hall).—Glass cases of ceramics.

Room 2 (Echo Room).—Samples of graphite and nephrite (jade), cases of ceramics and glass.

Room 3.—Collection of various models presented by the firm of Messrs. Schneider and Co., of Creusot.

Room 4.—Mining.—Ores, samples of coal, boring apparatus, methods of extraction, shaft sinking and ventilation, sorting and washing of the coal, miners' lamps, ventilators.

Room 5.—Metallurgy.—Ores, roasting of ores, hot air apparatus, ovens (coke, calcination, reverberatory, gas), blast furnaces and metallurgical furnaces for cast iron, iron and steel, Siemens-Martin and Bessemer steel, manufacture of lead, zinc and tin; smelting and moulding of metals; samples of metals.

Rooms 6, 7 and 8.—Metal Manufacture.—Forges, forge appliances, laminating rollers, plate rolling, forgings, sheetings, dishing, stamping, chiselling, rolling out, wire drawing, welding by electricity, alloys, moulding of metals, artistic casting; goldsmiths', jewellers' and engravers' work; galvanoplastics, cutlery, artistic locksmiths' work ; collection of weapons.

Room 9.—Woodwork.—Tools, sawing, cutting and shaping, samples of woods.

Room 10.—Various machines for and large models of public works; machinery and apparatus used for foundations ; hydraulic

*For the translation of the Notes which were in French, the Institution is indebted to Mr. F. R. Durham.

constructions ; bridges ; civil engineering : bridges, excavators, barrages, locks, viaducts, aqueducts, lighthouses and erecting apparatus.

Room 11.—Agriculture and agricultural machinery.—Agricultural implements : Rakes, spades, ploughs, scarifiers, rollers, harrows ; &c. ; agricultural machinery for sowing, mowing, hay making, corn cutting, threshing, &c. ; machines for extracting grain, and cleaning and storing it ; drainage and irrigation ; appliances for transport ; agricultural constructions ; dairy ; cheese-making ; agricultural products ; tools for forestry.

Room 12.—Museum of appliances for the prevention of accidents, and of industrial hygiene.

Room 13.—Building tools, building materials, labourers' tools and cranes.

Room 14.—Materials and models of public works ; labourers' tools ; cranes ; manufacture of plaster of Paris, lime and cement ; cordage ; samples of tiles and plaster models for teaching and decoration.

Room 15.—Carpenters and cabinet-makers' work ; scaffolds, gables ; iron and wooden trusses ; vaults, floors.

Room 16.—Carpenters' work ; gables, trusses, wooden staircases, doors and window frames, edifices ; instruments for geometric drawing.

Room 17.—Geometry and descriptive geometry.—Drawing and reducing instruments ; geometric figures ; paraboloids, hyperboloids ; plain and solid geometry.

Room 18.—Locksmiths' Work : Raw material ; manufactured material. Marquetry.

Room 19.—Surveying, Levelling, Topography, Geology.—Measures, surveyors' chains, theodolites, goniometers, graphometers, telescopes, plane tables, diastinometers, declinators, coordinatometers, sights, levels, stadia, stadiometers, tacheometers, cameralucida, telemetographs, watchmakers' tools, regulators, &c.

Room 20.—Topography, Watchmaking, and Astronomy.—Ancient and modern clocks and watches ; regulators ; machines for dividing straight lines and circles ; quadrants, clisimeters, compasses, theodolites, telemeters, terrestial and celestial globes ; the

solar system ; astrolabs, planispheres, planitaria, field glasses and telescopes, astronomic quadrants, equatorials, sextants and octants, marine compasses, &c.

Room 21.—Weights and Measures.—Appliances for verification and stamping French and foreign measures of length and capacity ; French and foreign weights ; weighing apparatus.

Room 22.—Museum of Social Economy.

FIRST FLOOR.

Room 23 (Salon Carré).—Works of the Applied Art School.

Room 24.—General Mechanics.—Windmills, water wheels, turbines, steam engines, various motors, governors, accessories of machinery, &c.; generators and their accessories ; engines and boilers for navigation ; locomotives, tenders, railway cars, brakes, rails, turn tables.

Room 25.

Room 26.—Mechanical Physics.—Weight, gravity ; parallelograms of forces ; levers ; impact of bodies ; centres of gravity.

Room 27.—Physics.—Hydrostatics ; pressure and flow of liquids and gases ; pneumatic machinery ; compressibility and elasticity, capillarity, chemical properties, heat, dilation, steam, conductibility, radiation, calorimetry, magnetic apparatus, electricity, chemical action, electric light, dynamic electricity, galvanic piles; action of currents, measurements of currents, induction, electro-magnetism, thermo-electric phenomena, &c.

Room 28.—Meteorology.—Barometers, thermometers, hygrometers, magnetometers, anemometers, electrometric apparatus, apparatus for meteorological optics, recorders.

Room 29.—Physics.—Acoustics: Theory of sounds, musical instruments.

Room 30.—Physics: Acoustics: Theory of sounds, musical instruments. Optics: Optical instruments. Galvanoplastics. Telegraphy: Optical and electrical telegraphy. Telephony.

Room 31.—Machine Tools.—Lathes, hand and power tools ; specimens of turned and worked wood.

Room 32.—Machine tools for drilling, boring, turning, milling, sawing, planing, stamping, cutting, splitting, screwing, boring, preparing metal and wood for working on ; guides, supports, &c.

Transformations and laws of locomotion ; gearing. Hydraulics : Hydraulic elevating machinery, pulsometers, fire engines, tread mills, chain pumps, hydraulic rams, &c.

Rooms 33 and 34.—Ceramics and Glass.—Faiences : Stoneware, china, glass and crystal ; engravings and enamels.

Room 35.—Glass.—Raw materials, glass blowers' tools, glass furnaces, mechanical glass blowing, sheet glass making; cylinders, tubes, pipes, &c. Shaping optical and watch glasses, &c. Specimens of glass and crystal goblets ; cast glass, engraved glass ; manufacture of mirrors and bottles. Artificial stones.

Room 36.—Ceramics.—Raw materials, kilns and various apparatus for brick, stoneware and china making ; fireproof pottery, crucibles, dull pottery, varnished pottery, enamelled faiences (common and fine), stoneware (common and fine) ; decorated or printed pieces ; colours ; gilding and application of various metals.

Room 37.—Dyeing.—Dyeing wood, dyeing materials, bleaching, hand printing, printing machinery, &c. Wallpaper manufacture. Chemical products. Models of various factories.

Room 38.—Exhibition of original apparatus of Lavoisier's Laboratory, and various models of the eighteenth century.

Room 39.—Paper manufacture.—Preparation of rags; pulp of rags, of straw, and of wood (chemical and mechanical) ; bleaching of the paper pulp ; sheet paper and manufacture of continuous paper.

Room 40.—Industrial Arts.—Engraving.

Room 41.—Industrial Arts.—Engraving, lithography, typography, printing, writing, &c. Photography.

Rooms 42, 43, 44, and 45.—Photography.—Photographic apparatus. Specimens by several processes of photography.

Room 46.—Chemical Industry.—Presses and wine presses ; soap making ; candle making ; tanning and chamois dressing ; animal black ; oil making ; brewing ; vinegar making ; cane and beetroot sugar making ; refinery ; confectionery ; distillation of alcohol from wine, from beetroot, from corn, &c. ; rectification of alcohols ; manufacture of starch ; mills ; bakery ; manufacture of illuminating gas ; acetylene ; woods and their preservation ; coal and agglomerates ; sulphuric acid ; oven for pyrites ; sal-ammo-

niac ; soda ; sodium sulphate ; chlorium ; rubber cutting, crœping, and sheeting.

Rooms 47, 48, and 49.—Spinning and weaving.—Textile and spun materials ; preparation of silk, of linen and hemp, cotton and wool ; spinning machinery ; specimens of thread and fabrics ; various patterns of weaving looms ; Jacquard mechanism ; ribbons and velvets ; gauze, chenille, net lace, hosiery, &c. ; drapery, hattery, &c. ; sewing machines ; collection of plain and fancy materials ; tapestry.

SECOND FLOOR.

Room 50.—Hygiene, Heating and Lighting.

Room 51.—Heating and Lighting.—Apparatus for mechanical observations ; dynamometers, pressure gauges, manometers, counters, water meters, anemometers.

Room 52.—Calculating apparatus and tables ; calculating machines.

Room 53.—Industrial designs.

Room 54.—Gearing.

PHYSICAL LABORATORY.

In the Physical Section the following work is carried out :—

Metrology.—Calibration ; length determination ; study of screw threads. Calibration of weights up to 1 kg. Verification of sextants.

Optics.—Study of focal constants, and of the various properties of lenses or optical systems. Determination of indices of liquids or solids.

Photometry.—Determination of intensity and of luminosity of all kinds of light (except electric).

Photography.—Study of photographic lenses.

Thermometry.—Calibration of thermometers from 0° to 400° ; calibration of thermo-couples and of pyrometers up to 1,400°.

Calorimetry.—Determination of calorific value of all fuels.

Barometry.—Calibration of mercury and aneroid barometers.

Manometry.—Calibration of manometres up to 25 kg.

Meters.—Calibration of water meters, &c.

SECTION OF METALS.

The Section of Metals is devoted to the following :—Tests in

tension (static or by impulse on bars); test piece compression (metals, metallic cables, compound cables); bending (flat mine cables, copper, wood, rubber, chains, &c.). Torsion, shearing, stamping. Friction experiments with oils and metals. Working metals while hot. Annealing, tempering, fusion, &c. Tests for density, hardness, &c. Microscopic examination of metals and other bodies. Tests of floors, bridges, joists, &c.

A 300 ton testing machine, 39 metres long, is provided for experiments in compression, torsion, and bending.

SECTION OF MATERIALS.

In this section are conducted experiments applicable to materials or of interest to manufacturers. It contains all the apparatus requisite for the trial of manufactured goods, as well as of the materials used in their manufacture.

MACHINERY SECTION.

In the Machinery Section experiments on the following can be carried out:—

Steam: Boilers with smoke consuming grates; various machines; electric generating plant, and all accessories of engines and boilers.

Internal Combustion Engines: Gas, petrol, producer gas, spirit, alcohol, acetylene, and all their accessories.

Compressed air machinery, pneumatic tools, &c.

Hydraulic machinery, engines, turbines, &c.

Pumps (plunger, centrifugal, rotary, &c.).

Water meters for large supplies, hot water meters for all supplies, spirit counters, &c.

Verification of manometers, gas meters, counters, tachymeters, tachygraphs, indicators, &c.

Tests of conducting and non-conducting materials.

Aerial screws.

Motor cars and all their accessories.

Lifts. Heating and warming appliances. Conveyors, elevators, &c.

Measurement of friction.

Tests of belting and power transmissions of all kinds.

After each experiment an official report is delivered, and is the exclusive property of the client.

SECTION 5.

The chief object of Section 5 is the investigation and testing of new and insufficiently known vegetable matters, comprising more especially the study of new fatty matters (oleoginous grains, fats or oils, soap derived from same),raw gums, rubber and gutta-percha, new textiles, essential oils, resins, tanning materials. The section contains apparatus on a reduced scale, forming a small factory where fats and rubber can be treated under the conditions of practical industry. Here also analyses of lubricating oils and fuels are conducted, and the chemical analyses rendered necessary by the experiments executed in the other sections of the laboratories are carried out.

MOTOR CAR WORKS OF MESSRS. DE DION BOUTON.

The works of de Dion Bouton, at which nearly 3,000 workmen are employed on work of a most varied description, cover an area of about 10 acres.

Following the logical order of manufacture, the visit will commence by the inspection of the power station. This station contains 7 gas engines, developing 350 H.P., and supplied from a complete gas generating plant (generators, gasholders, scrubbers, &c.). These engines drive dynamos, which in turn supply current for driving the machinery in the various shops.

Besides this plant there is a reserve electric installation, driven by current supplied from the "Ouest-Lumière" Company.

Next will be visited the automatic tool shop, where the most up-to-date plant will be seen, cutting gears, &c., with absolute accuracy. Thence the lathe and machine shop, where the various parts, emanating either from solid bars of steel or from the foundry and stamping machinery, are worked up and passed on to the erecting shops.

There the engines, the change speed gears, the motors, &c., are assembled, adjusted, and fitted to the chassis.

In the chassis shop the fine arrangement for the erection of the chassis can be observed in all phases of manufacture, from the bare frame work of a stamped plate up to the point where only the wheels and the body are required to make the car ready for the road.

The erection of the chassis, in view of its importance, is carried out in two stages: in the first shop the whole of the mechanical parts, gearing, &c., and in the second, the pipeage, reservoirs, wheels, &c. In this latter shop the trials of the finished chassis are carried out; for a motor car is never supplied until it has been thoroughly tested and found satisfactory.

In the motor shop both the manufacture and fitting are executed. The final boring of the cylinders by means of grinding machinery of an entirely new type, is of great interest.

The experimental mechanical and chemical laboratory, where the various tests are made, is the most complete installation in France. The laboratory contains a special department of micrography, for the study of new alloys, and thus renders a service to science and trade.

Then the tempering ovens, with their water and oil cooling arrangements and methods of temperature determination, will be visited, as well as a small shop where the sparking plugs, &c., are made.

Finally the erection shop for the heavy type of motor lorries, vans, &c., for all purposes, will be visited.

MUNICIPAL METROPOLITAN UNDERGROUND RAILWAY, PARIS.

The Crossing of the River Seine by Line No. 4, from the Porte de Clignancourt to the Porte d'Orleans.

The Line No. 4, from the Porte de Clignancourt to the Porte d'Orleans, which includes the crossing of the River Seine (under construction), is one of the principal arteries of the Municipal Metropolitan Railway. This line is entirely below ground, crosses

Paris from north to south, following one of the most important lines of communication. It serves the Gare du Nord, and de l'Est, Central Markets, the City, the Boulevard St. Germain, and the Gare Montparnasse.

This section of the line, which includes the tunnel under the River Seine and the approaches on either side, commences at the crossing of Rue des Halles and Rue St. Denis, passes below Line No. 1 in the Rue de Rivoli, crosses the Place du Châtelet, traverses the main arm of the River Seine, the Ile de la Cité, the small arm of the River Seine, passes below the Railway Paris-Orleans, then crosses the Place St. Michel, and, following the Boulevard Saint André and the Place Saint André-des-Arts, reaches Rue Danton, whence it continues as far as the Boulevard St. Germain.

Along this distance of about 1170 yards the line passes through the water-bearing strata at a considerable depth. The difference of level between the rail and the ground is 65·5 feet at the Place du Châtelet, 65 feet at Marché aux Fleurs, 51 feet at the Place St. Michel, and 36·5 feet below the River Seine.

There are two deep stations, provided with lifts, on this line, the one in the City, on the Marché aux Fleurs, the other on the Place St. Michel.

The two-track tunnel has the same cross-section as the standard of the Municipal Metropolitan Railway. At the same time, the lining of this work, instead of being built in masonry, has been constructed as a tube of cast-iron rings, 2 feet in width, made up of 13 sections, with an arc length of 6 feet, with the exception of the key section, which has only 1·65 feet arc length. These plates have a thickness of $1\frac{9}{16}$ inches; they are stiffened along their edges by webs, varying in height from $4\frac{3}{4}$ to 9 inches, which form the flanges for bolting the plates together. The voids between the webbings will be filled out with concrete, which will be rendered afterwards to a thickness of $1\frac{3}{16}$ inches.

With the exception of the sub-fluvial part and the crossing under the Railway Paris-Orleans, the two-track tunnel has been constructed partly by aid of a shield.

In sub-fluvial sections the cast-iron lining of the tunnel is carried on steel trusses, spaced 4 feet apart, and tied together by longitudinal girders buried in concrete. The construction has at

its base a working chamber, for excavation under compressed air, after the usual manner of sinking vertical caissons. As it was not possible to construct the Seine crossing with one single caisson, three caissons, 31·5 feet wide, 29·5 feet high, and 118, 126 and 143 feet long, were used on the main arm, and two caissons, 65 feet long, on the small arm.

The work of sinking these caissons, both on the main and small arms, is now finished.

It was not thought possible to sink the caissons one after the other in such a manner as to form a close joint; in fact these caissons are separated from each other by spaces of about 5 feet in width, so that after completion of the sinking operations, there remains the joining up of the sections of the tunnel. These connections have been executed by means of movable caissons. The work was commenced at the sides of two consecutive tunnel sections, with two walls in bond of concrete, which crossed from one to the other, thus closing laterally the space of 5 feet which separated them. These walls are finished off at the level of a horizontal platform, which superposes for a short length the ends of the tunnel caisson. In this manner a support in the shape of a hollow rectangle was obtained for a third movable caisson. Under shelter of this latter caisson, the work of joining up the tunnel sections has been completed.

These connections between the consecutive caissons in the bed of the main arm of the Seine have been completed. The same work is now being carried out on the connection of the left bank with the quay walls of the Cité. There still remains to be made the connections between the two caissons of the small arm, and to complete the continuity between the various sections of the work by the removal of the end shields at the ends of the caissons.

At the crossing of the Railway Paris-Orleans, near the small arm of the Seine, it is proposed to have recourse to the freezing process, on account of greater security. The water-logged subsoil will be frozen, and the construction of the line will be cut out in the solidified ground. The Stations "La Cité" and "Place St. Michel" include special works, having an interior width of 41 feet and 24·5 feet height from rail to soffit, and comprise two tracks and two platforms. These works consist of a steel frame-

work of trusses, spaced 4 feet apart, tied together by means of longitudinal girders buried in concrete. Behind the internal lining of stoneware cubes, the water-tightness is secured by means of steel plate tube. The construction, after the erection of the steel-work and concrete, has been sunk vertically by means of compressed air.

These works for the Stations "La Cité" and "Place St. Michel," 216 feet long, have been completed. The ends of these stations will be connected up to the two-track tunnel, and have been so designed to hold the staircases and lifts for the passengers.

These works consist of large elliptical wells, the major axis being 85·5 feet long, and the minor axis 61 feet. After the completion of the steelwork and concrete, they will be lowered to their final level vertically by means of compressed air. These works are likewise finished.

THE EIFFEL TOWER.

The Eiffel Tower consists essentially of an iron pyramid composed of four great curved columns, independent of each other, and connected together only by belts of girders at the different stories, until the columns unite at the top of the tower, where they are connected by ordinary bracing. The leading principle followed in the design was that adopted by M. Eiffel in all his lofty structures, namely to give the corners of the tower such a curve that it should be capable of resisting the transverse effects of wind pressure without necessitating the connection of the members forming the corners by diagonal bracing.

The actual work of the foundations was commenced in January, 1887; but a great number of borings had previously been made on the Champ de Mars, which revealed the existence of a bed of hard compact clay 52 feet thick, resting on a chalk substratum, and capable of carrying with safety a load of from three to four tons per square foot. The bed of clay dips slightly from the École Militaire towards the Seine, and underlies a deposit of compact sand and gravel, which affords good material

for foundations. At the two foundations furthest from the river the bed of gravel is about 18 feet thick; but at the other two it is much reduced in thickness, and is only met with at a depth of 16 feet below the mean water level of the Seine, being overlaid moreover with soft and permeable deposits, and in these cases it became necessary to employ caissons sunk by the aid of compressed air. The piers are numbered 1, 2, 3, 4, and are respectively north, east, south, west; the east and south piers are the two furthest from the river, which here flows from north-east to south-west. At these two piers the gravel was met with at a depth of 23 feet. At the north and west piers the sinking was carried through the thinner gravel, and the foundations were made on the underlying bed of fine sand. Each of the four foundations consists of four component piers, which in general are erected on a mass of concrete 32 feet 9 inches long, 19 feet 8 inches wide, and 6 feet 6 inches thick. For one component pier in each foundation, however, the concrete is 46 feet long by 24 feet wide, being prolonged to the centre of the main pier, so as to form a platform for the elevator machinery. Each component pier is built with one face vertical towards the centre of the tower, the outer corresponding face being inclined at the same angle as the column of the tower; the two other faces are vertical and parallel, and the top has been made at right angles to the outer face and therefore normal to the springing of the column. Two bolts, about 4 inches diameter and 4 feet 10 inches apart, are built to a depth of 20 feet into the piers, and are secured to mooring plates 8 inches deep. The concrete used was Boulogne cement; the bedstones on the tops of the piers are from the quarries of Château-Landon, and have a crushing strength of about 17,500 lbs. per square inch, whilst the maximum load to which they are exposed does not exceed 427 lbs. per square inch. The load on the ground beneath the masonry of the piers is from 3·0 to 3·4 tons per square foot. The centres of the four component piers of each foundation are 49 feet 2½ inches apart, and the four foundations form a square of about 412 feet side. The work on them lasted about six months, during which 40,000 cubic yards of earth were excavated, and 16,000 cubic yards of masonry completed.

The erection of the lower portion of the columns was effected without difficulty, and the only appliances employed were derricks and winches. The former, though 72 feet in height, were of the simplest possible construction and were made of timber. The four standards, placed one at each angle of the four columns, measure about 31 inches on a side, and were delivered on the ground in lengths weighing from two to three tons; these were handled by means of the derricks, and were bolted one upon the other as the work advanced; the standards were connected by the permanent cross-bracing, which held them in position and consolidated the structure. The bolts by which the various pieces were first connected together were afterwards replaced by rivets, as soon as it was ascertained that the different parts of the work were in their proper places. When a height of 50 feet was reached however, this plan had to be abandoned; and for the remainder of the work to the summit cranes were employed which were fastened to the work and carried up as it proceeded. These cranes consisted of a long arm, turning on a pivot, and mounted on a frame in the form of a triangular pyramid upside down; the pivot supported a long vertical post, to which the crane arm was hung at about half its length; and the post carried a platform, from which the crane was worked; at the bottom of the frame was another small platform. As the work of building up the columns advanced, there was erected within each of them an inclined path following the same angle as the column, and consisting of two girders, the upper flanges of which were intended to serve as a roadway for the elevators; the upper flanges of these girders were pierced with a series of holes at equal distances apart to allow of the crane being fixed to them at any desired height. Similar holes were made in the lower framework of the crane, which could thus be bolted to the girders and held securely in place. As soon as all the pieces within range of the crane had been raised and riveted, the crane itself was moved upwards: a strong iron cross-beam, through the centre of which passed a screwed bolt, was secured at its ends to the two elevator girders about 8 feet above the crane; the bolt which passed through the hole in this beam was attached to the crane, and its nut was put in place above the beam; the

fastenings of the crane to the riveted work were then removed, leaving it suspended by the screw alone, so that it could be raised to its new position by simply rotating the nut on the screw; after which the crane was again secured, and the cross-beam removed. Four of these cranes were used up to a height of 380 feet, but beyond this two only were employed on a somewhat modified plan. Each crane weighed 12 tons, and had a normal working load of about 2 tons. When 98 feet height was reached, it became necessary to prevent the inclined columns from falling over by their own weight. For this purpose a strong scaffolding 100 feet high was erected on timber piles, driven into the ground to prevent settlement; by these the columns were supported on their inner sides through the intervention of sand boxes, such as are commonly used for the centres of arch bridges. These were found useful for allowing the different members to be easily adjusted when necessary. Altogether twelve stagings were erected, 20,000 cubic feet of timber being employed in their construction; this, however, was all the scaffolding required, for as soon as the first storey was completed which is 189 feet above the ground, the four columns mutually supported one another. To facilitate the erection of the second storey, a circular railroad was laid down on the first floor, as well as a 10 H.P. portable engine working a crane, from which the chain passed through a square opening in the centre of the platform; and the ironwork when delivered on the ground was hoisted by this crane into wagons on the circular railroad, and distributed by them to the different columns, into which it was raised by the cranes already described. As the work advanced, the dimensions of the iron became lighter and the progress more rapid. A height of 380 feet was reached on 14th July, 1888, where the second storey is situated. From this point two cranes only could be used, and they were braced firmly together, so as to form in a manner a single structure. The time required to raise them into a fresh working position was forty-eight hours; once fixed, no further change of position was necessary until a complete panel from 30 feet to 40 feet in height had been erected. In addition to these two rising cranes and the one on the first storey, another was erected on the second storey, and still another

on the midway platform which was constructed when a height of 643 feet had been reached. During all stages of the work movable platforms were employed, which could be placed in any desired position, so as to bring the riveters within reach of their work. These platforms were protected by handrails and screens, and the precautions taken were such that one man only is said to have fallen from them during the whole course of the work.

The tower terminates at a height of 906 feet above the ground with a platform about 53 feet square; the width of the column at this level is 33 feet, the gallery being carried by brackets which project sufficiently to afford a considerable area of platform. Above the platform rises the campanile, in the lower part of which is a spacious and well equipped laboratory, intended for the prosecution of scientific researches. Four arched lattice girders rise diagonally from each corner of the tower, and unite at a height of about 54 feet above the third or top platform. By means of a spiral staircase, yet another small gallery is reached, about 19 feet diameter, surrounding the lantern which crowns the edifice and brings the total height of the structure to 984 feet. Provision is made for protecting the structure from lightning by cast-iron pipes 19 inches diameter, which pass through the water-bearing strata below the level of the Seine to a depth of 60 feet, their upper ends being connected with the ironwork of the tower. The total weight of wrought and cast iron used in the structure is 7,300 tons, not including the weight of the caissons employed in the foundations nor of the elevator machinery. Iron, and not steel, was used in the construction throughout.

The first storey, which has an area of 38,000 square feet, is chiefly occupied by restaurants. The second floor, with a surface of 15,000 square feet, is surrounded by a covered gallery 8 feet 6 inches wide, having a total length of 490 feet. The central portion of this floor is occupied by the elevator service, considerable space being necessary to provide for the ascending and descending traffic. On the top platform of the tower there is a large hall covered in on all sides with glass, from which, when the weather is favourable, a magnificent panorama is visible.—*Proc. I.Mech.E., 1889.*

ELECTRIC POWER STATION ST. DENIS

OF THE

SOCIETÉ D'ELECTRICITÉ DÉ PARIS.

The electric generating station at St. Denis was completed towards the end of 1906, and comprises a large power station for supplying current to the underground railways of Paris; for manufacturers; tramways, &c. It has further been erected with the object of selling current in bulk to other Parisian companies when they require more power than their present stations can give.

The works are divided up into three groups of buildings: coal-stores, boiler-houses and electric generating plant houses.

The total power comprises twelve sets of machinery, each capable of giving out 6,000 KW., or on an overload up to 7,300 KW. The generators are of the Parsons' steam turbine type, as manufactured by Messrs. Brown, Boveri and Co.

The coal-stores consist each of four silos, holding 4,000 tons of coal.

The boilers are of the Babcock-Wilcox type, twenty-four in number, with automatic feed on the chain grate system.

The current supplied consists of three-phase current at 10,250 volts pressure and 25 periods per second; two-phase current at 12,300 volts pressure and 42 periods per second; and lastly, continuous current at 230 and 550 volts pressure.

The station is equipped with a complete installation for coal-handling and ash disposal.

MESSRS. SCHNEIDER AND COMPANY'S WORKS AT LE CREUSOT.

The Creusot Works occupy an area of about 3,300 acres and extend uninterruptedly for a distance of three miles. The different services are connected by a system of railways 200 miles in length, with a rolling stock of 55 locomotives and 1,600 cars. The following figures give some idea of the importance and varied character of Messrs. Schneider and Company's Works:—

Production in 1907:

Iron and steel plates	150,000 tons.
Armour plates	6,000 ,,
Ship construction, bridges and iron works	12,000 ,,

The number of employees of all classes varies from 15,500 to 16,000.

Coal is raised from several pits, varying in depth from 1,100 to 1,400 feet.

The manufacturing departments can be roughly divided into three subdivisions: The first comprises the blast furnace and steel plant; the second the rolling mills, steam hammers, &c.; and the third the electrical works, the gun-making shops and the firing grounds.

Blast-Furnace Department and Steel Plant.—The blast-furnace department includes five furnaces in blast; of these three are for the Bessemer-Thomas process, and two produce forge pig or pig for ordinary work according to requirements.

The steel department comprises four independent groups of workshops: (1) For the manufacture of steel in ingots and for special castings; (2) For the forging of heavy pieces, with a full plant for cementation, tempering and reheating; (3) Machine shops for finishing all classes of steel work; (4) The wheel-tyre shops.

For the largest ingots, the weight of which may exceed 120 tons, a special casting pit has been provided. At one end of this pit a large liquid steel hydraulic press of 10,000 tons capacity is installed. Annexes to the first group of the steel works include a foundry where machine parts and other complicated castings are produced, as well as castings for gun mountings, stern frames, and other pieces required for ship construction. The tempering-shop, which is placed near the main forge, contains special furnaces for heating armour plates, gun parts, &c.

The 100-ton steam hammer of Creusot was the largest of its kind when it was erected. Its maximum power can be raised to 120 tons.

In the fitting-shops the most important operations are in connection with armour-plate work, gun-making, &c.

The fourth group of the steel works contains shops for making tyres. They are connected to the ingot foundry by a tunnel 400

yards in length, in which rails are laid to allow the rapid transit of the ingots. The Creusot rolling-mill department covers a space of over 40 acres, of which 25 acres are occupied by buildings. 3,500 workmen are employed here; motive power is generated by 150 steam engines, having a total capacity of 12,000 horse-power.

The plant has been arranged to obtain systematic and continuous working, and to avoid the carrying backward and forward of the material under treatment. For instance, as regards the manufacture of iron, from the point of arrival of the pig until the rolled material reaches the delivery wharf, a straight line is followed through the puddling furnaces, the shingling hammer, the roughing rolls, the shears, the piling, the reheating furnaces, the finishing rolls, the inspection platform, and the delivery on the railway trucks. Since 1869 steel has gradually superseded iron, and at the present time nearly three-fourths of the products manufactured at the rolling mills are of steel. The ingots, as a rule, are received hot from the steel works and are distributed among the various mills for direct rolling.

All the mills for finished products, bars, sheets, and plates are placed under the large bay of the main building and occupy the whole length. This length, 1,400 feet, was found insufficient some years since and a second parallel line of mills has been put up for sheet rolling. All the mills are fitted with three-high rolls.

Iron Foundries.—The construction department comprises three iron foundries, each having its own equipment. For the 100-ton steam hammer certain castings weigh over 100 tons, and special means have to be resorted to for casting such heavy pieces. For doing this two cupolas have been erected on a level above the floor level of the foundry; these two cupolas can each melt 10 tons per hour. As the charges are melted they are poured into two reservoirs, each holding 50 tons. The bottoms of these reservoirs are also above the level of the foundry floor. When everything is ready for casting the iron is allowed to flow by gravity to the mould. The cranes are required only for carrying ladles containing a small quantity of cast iron for feeding.

The smith's shop is fitted up with furnaces and steam-hammers for the working of steel ingots, the weight of which does not exceed 10 tons.

Fitting and Erecting Shops.—The fitting and erecting shops are the largest in this department. They contain more than 500 machine tools of all kinds. Owing to their importance, these shops have been divided into two main sections; one for locomotives, small stationary engines, and torpedo-boat engines; the other for large marine and stationary engines. The section which deals more especially with locomotive work comprises eight buildings, three of which contain lathes, four other machine tools, and one for erecting. The section more especially set apart for the construction of large stationary and marine engines comprises 10 buildings; they are divided into turning shops, drilling, boring and general machine shops and one for erecting. These shops contain all the machine tools for machining exceptionally large work. Among others are a squaring-up lathe, capable of turning up to 33 feet in diameter, lathes and boring machines which can take shafts 82 feet long, a boring machine to finish boring cylinders 10 feet in diameter by 17 feet high, a machine for the cutting of double-helical teeth on wheels 10 feet in diameter; a planing machine that can work pieces 11 feet 6 inches wide by 32 feet 10 inches long, &c.

The manufacture of the various tools which are necessary for the machine shops is centralized in one special building, fitted up with the necessary appliances for this work.

The electric-construction department consists of two main shops situated at the south end of the works. One of these serves for the fitting of all mechanical parts of small and medium-sized electric machines and for the erection of large dynamos: One of the bays of this shop is specially set apart for stamping, cutting out and putting together dynamo sheets. It contains punches, lathes and hydraulic presses the largest of which are adapted for finishing drum armatures up to 10 feet in diameter. The erection of small and medium-sized dynamos, fitting of accessory devices and winding are carried out in the other main building.

Ordnance Shops.—The artillery or ordnance shops cover an area of over 35,000 square yards, and are divided in two groups (north and south) of three spans each. The north group machines large and medium-sized guns, coast-defence gun carriages, gun mountings, ships' turrets and turrets for land service. The south group is used for the construction of field and siege artillery.

Among the largest machine tools may be mentioned two gun-boring machines of 50-foot travel and 48-inch height of centres; a lathe 56 inches height of centres, and 50 feet between centres, and one lathe that can turn up to a diameter of 46 feet. These tools are employed for machining guns of the largest calibres. Among the larger plate-working machines, there is one 150-ton hydraulic press for stamping gun-carriage cheeks, a hydraulic riveting machine, and two special hydraulic presses for putting on the bands of projectiles. The plant is completely equipped with full sets of all the necessary gauges, standards, instruments of precision, &c., required in the manufacture of ordnance. *American Machinist, 20th June, 1908.*

WORKS OF THE SOCIÉTÉ DES FORGES ET CHANTIERS DE LA MEDITERRANEÉ AT LE HAVRE.

The works at Havre are equipped for the complete construction of all types of engines of all sizes for naval, military and merchant service, from the largest ironclad cruiser to a small cargo boat.

Mechanical appliances, such as dredgers, bucket and suction, hydraulic apparatus, cranes, &c., for harbours and ports are likewise constructed, as well as pumping machinery for town supplies, steam engines for manufactories, coal briquet machinery, &c.

The total equipment is such that the largest forgings and castings can be manufactured. The works employ about 1,000 workmen and staff.

At the time of the visit there were seen under construction the marine engines for three large cargo boats, a large dredger for the Suez Canal and the Port of Havre, a large lift for the Canal de l'est, and the complete engines and boilers for four vessels for the French Navy and two large Parsons' turbines for two torpedo destroyers of the French Navy.

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(Incorporated.)

Telephone—
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39 VICTORIA STREET,
WESTMINSTER, S.W.

Journal and Record of Transactions.

[*The Institution as a body is not responsible for the statements made or opinions expressed herein.*]

5th September, 1908.

ANNOUNCEMENTS.

WEDNESDAY, 14th October, at 7 p.m. Visit: Messrs. Siebe Gorman and Co.'s Submarine Engineering and Diving Apparatus, Works, 187 Westminster Bridge Road.

MONDAY, 19th October, at 7 p.m., at the Royal United Service Institution, Whitehall, **Annual General Meeting of the Institution,** followed by the **Annual General Meeting of the Benevolent Fund.**

At **8 p.m.** a Paper on "**Hydraulic Plate Cutting and Riveting Machines,**" by Mr. N. S. TRUSTRUM *(Member)*, will be read with a view to discussion.

SATURDAY, 31st October, at 3 p.m. Visit: The Works of the **Limmer Asphalte Paving Company** at Blackwall.

HONORARY MEMBER. The Council have the honour of announcing the election of **Monsieur Eugene Schneider,** of Messrs. Schneider and Co., Le Creusot, as an Honorary Member of the Institution.

FRIDAY EVENING RE-UNIONS. The Rooms of the Institution are kept open every Friday evening during the months of October to May inclusive, for the purpose of social intercourse.

PERSONAL NOTES.

HERBERT J. BROCK has arrived home from British Nyassaland.

H. L. BUTLER is now engaged with Mr. A. S. E. Ackermann, of 25 Victoria Street, Westminster, S.W.

STAFFORD X. COMBER, of the McArthur Bros. Construction Company, Chicago, who made a visit to England for the Olympic Games, has been appointed inspecting engineer for a new steel railroad bridge to be constructed across the Esopus River above Bishop's Falls, New York State. The Bridge, which will be over 390 feet long and about 80 feet high, will consist of five steel towers resting on masonry piers sunk to bed-rock, and four girder spans. The work will be carried out by the American Bridge Company, for the McArthur Bros. Company, in connection with their contract for the Main Dams for the Ashokan Reservoir. Address for mail, S. X. Comber, P.O. Box 17, Brown's Station, New York, U.S.A.

W. E. LILLY is acting as one of the Secretaries of Section G "Engineering" for the Dublin meeting of the British Association to be held from 2nd to 9th September.

T. L. MANUELIDES has entered the office of Messrs. Norris and Henty, 87 Queen Victoria Street, E.C.

JOHN T. MORRIS, Professor of Electrical Engineering at the East London College, communicated to last month's number of "The Illuminating Engineer" the results of some tests made on some low and high pressure incandescent gas lamps conducted under his supervision.

JOHN T. NICOLSON (*Hon. Member*), is joint-author with Mr. Dempster Smith of "Lathe Design for High and Low-speed Steels," a work which is the outcome of the experiments on the durability of tool steels and the researches upon the cutting forces acting upon lathe tools carried out at the Manchester School of Technology.

JAS. OSWALD, at the fifth annual meeting of the British Foundrymen's Association held at Newcastle-on-Tyne last month, was re-elected a Member of its Council.

C. A. SMITH (not Chas. A. Smith as stated in our last issue) was the author of the Paper on "A Method of Detecting Bending of Columns," read at the Bristol meeting of the Institution of Mechanical Engineers. The three Lectures on "Suction Gas Plants," which he gave at the East London College, are shortly to be published in book form by Messrs. Griffin and Co.

W. A. TOOKEY is the author of a recently published work entitled "The Gas Engine Manual: a practical Handbook of Gas Engine Construction and Management."

W. C. WEDEKIND and Mr. F. J. BOLD have been appointed Managing Directors of the new firm of Messrs. Hermann Wedekind Ltd.—an amalgamation of the businesses of Messrs. F. J. Bold and Co. and Mr. Hermann Wedekind.

Appointments.

233. Young mechanical and electrical engineer with college education, works and power house experience, expert draughtsman and linguist, seeks appointment with good prospects, or would undertake a spare time occupation.

234. Constructional engineering draughtsman, age 25, desires change to improve position. Eight years experience with London firm. Knowledge of mechanical, electrical engineering, surveying, estimating and entire management of contracts.

Library.

Since the last announcement of donations to the Library, the following have been added :—

Architects, Journal of the Royal Institute of British, Part II., Volume XV. ; from the Institute.

Australia, Western, Geological Surveys, Bulletins No. 27, Palæontological Contributions to the Geology of Western Australia ; No. 28 Geology and Mineral Resources of Lawlers, Sir Samuel and Darlot, Mount Ida and portion of Mount Margaret Goldfield, with maps and plans ; No. 29, Report upon the Geology, together with a description of the Productive Mines of the Cue and Day Dawn Districts, with maps and plans ; No. 30, The Distribution and Occurence of the Baser Metals in Western Australia ; from the High Commissioner for Western Australia.

Aviation. Les Progrès de l'Aviation Par le Vol Plané, by Capitaine F. Ferber ; from the Author (*Hon. Member*).

Canada, Royal Atlas of ; from His Excellency the Governor of Canada.

Carburetting as determined by Exhaust Gas Analysis, The Principles of, by Dugald Clerk, M.Inst.C.E. ; (*Paper*) from the Author (*Past-President*).

Civil and Mechanical Engineers' Society, Transactions, 49th Session, 1907-8 ; from the Society.

Civil Engineers, Minutes of Proceedings of the Institution of, Part 4, 1906-7, Vol. CLXX., and Part 1, 1907-8, Vol. CLXXI. ; from the Institution.

Civils de France, Cinquantenaire (1848-1898) de la Société des Ingénieurs (in French); from Sir J. Wolfe Barry (*Past-President*).

Curves, Tables for Setting out, by H. Williamson ; from the Publishers, Messrs. E. and F. N. Spon.

Eiffel Tower, description of Construction and Volume of Illustrative Plates ; from Monsieur G. Eiffel.

Gas Engineers, Institution of ; Transactions, Volume 1907 ; from the Institution.

Gas Engine Manual, The, by W. A. Tookey ; from the Author (*Member*).

Gas and Petrol Engines, The Present Position of, by Dugald Clerk, M.Inst.C.E., F.C.S. (*Past-President*) ; (*Paper*) from the Author.

Gazetteer of the World, Longman's, edited by George G. Chisholm, M.A., B.Sc. ; from Mr. Charles Spon (*Member*).

"Lightning," Volumes IX. to XVIII. inclusive; from Mr. G. C. Pillinger.

Machine Design, Construction and Drawing, by Prof. Henry J. Spooner, M.I.Mech.E. (*Hon. Member*); from the Publishers, Messrs. Longmans, Green and Co.

Mathematical Tables, Aldum's Pocket Folding ; from the Publishers, Messrs. E. and F. N. Spon.

Mechanical Engineers, American Society of, Transactions, Volume 1907, from the Society.

Mechanical Engineers, Institution of, Parts 3-4, Minutes of Proceedings, 1907 ; from the Institution.

Mechanical Engineer's Reference Book, by H. H. Suples, B.Sc., M.E. ; from the Publishers, Messrs. J. B. Lippincott Co.

Municipal School of Technology, Manchester, The Journal of, Part 1, Volume I. ; from the School.

National Physical Laboratory, Collected Researches, Volumes III. and IV., and Report for the Year 1907, from the Directors.

Navigation and Nautical Astronomy, A Treatise on ; compiled by Staff-Commander W. R. Martin, R. N.

Philosophical Society of Glasgow, Royal, Proceedings of the, Volume 1906-7 ; from the Society.

Pont Alexandre, Notes sur la construction du, by MM. Résal and Alby, two Volumes (in French) ; from Sir J. Wolfe Barry (*Past-President*).

Quebec Bridge Disaster, by W. E. Lilly, D.Sc.; (*Paper*) from the Author (*Member Council, Ireland*).

Railway Surveying, Handbook on, by B. Stewart; from the Publishers, Messrs. E. and F. N. Spon.

Society of Engineers, Volume 1907 Transactions ; from the Society.

Steam Engine, The Marine ; by the late Richard Sennett and Henry J. Oram.

Steel, The Cohesion of, and on the Relation between the Yield Points in Tension and in Compression (*Pamphlet*), by G. A. Gulliver, B.Sc. ; from the Author.

Switchboard Measuring Instruments, by John C. Connan ; from the Publishers, Messrs. E. and F. N. Spon.

Tube Railways, Setting out of, by G. M. Halden, A.M.Inst.C.E. ; from the Publishers, Messrs. E. and F. N. Spon.

Wasserversorgung der Stadt Bukarest und Vorschläge zu ihrer Verbesserung und Ergänzung, Allgemeiner Bericht uber die

(*in German*), by W. H. Lindley; from the Author (*Past-President*).

Water Supply for Country Mansions, by Frank R. Durham, A.M.I.C.E.; (*Paper*) from the Author (*Chairman*).

Water, a Treatise on Building in, by George Semple; from Sir John Wolfe Barry (*Past-President*).

Water Board, Metropolitan, Fifth Annual Report of the, 1907-8; from the Board.

Worms, Description of the Harbour Works at, 1890-1895 (*in German*); from Mr. Edwin O. Sachs.

CHAS. H. SMITH,
Hon. Librarian.

NOTES AND QUERIES.

12.—TIMING OF A MACHINE WITHOUT A COUNTER.

L. H. HUGHES (Member), (Innieshall, Southend-on-Sea), writes:—The limit of rapidity in revolution counting, without a counter, is determined by the observer's ability to utter the numbers aloud or to repeat them mentally. Let the observer select some regular beat, or watch or feel some regularly moving part of the machine, and count 1, 2, 3, 4—1, 2, 3, 4 over and over again, beating time with foot or hand at each recurring "1." When the foot or hand is in synchronisation with the machine, stop the 1, 2, 3, 4 counting and start counting the foot or hand beat, commencing 0, 1, 2, 3, 4, and continuing 1, 2, 3, 4, which can be maintained automatically in action as long as required. The total beats counted during a stated period multiplied by 4 will give the speed. I have continually used this method with success for speeds up to 530 revolutions per minute, and believe it would be possible to employ it for counting speeds as high even as 600 per minute. The maximum possible will of course depend on the observer's degree of sensitiveness of rhythm, and it is obviously imperative for accuracy that entire attention be concentrated on what is being done. In noting the period of time it must be remembered that it coumences with the zero of the foot or hand beat counting.

13.—THE SELF-SHOOTER.

L. H. WILKINS (Member) of the Mother Lode Consolidated Gold Mines, Ltd., writes:—El Dorado County, California, will always be famous as the scene of Marshall's discovery of gold and the earliest beginning of the modern

era of gold mining. The country that was not only the first great modern producer but proved to be the pioneer in the invention of gold-saving appliances was eclipsed and well-nigh forgotten in its infancy by the discovery of the precious metal in Australasia. How different would be the task of the historian if the Antipodean discoveries had been delayed for a decade. As it was, the vast majority of the young, go-ahead, and intelligent miners of El Dorado and adjoining counties, rushed off to the new field—never to return. Those remaining, with the old-time conservatism of the Sierra Nevadas, continued work by the methods then in vogue and stubbornly set their faces against any kind of innovation. Hence it is that the Pacific slope offers to the mining student a sharp contrast between the methods of '49 and those of the present day. It is, therefore, quite refreshing to record the fact that El Dorado County is once more to the fore with a clever invention by a Californian working miner for the extraction of placer gold from mother earth, on a wholesale scale, with a minimum amount of labour.

The invention may briefly be described as follows:—A couple of miners select one of the numerous canyons and divert the creek by means of boxes, leaving the bed free for building the "self shooter." With 3 feet planks a sluice box is then built in the middle of the creek bed. This box varies in size, but the standard is 12 feet by 12 feet by 8 feet, with a platform 10 feet high, covering that half of the floor of the end of the box facing down creek. The bottom of the sluice gate rests against this platform. The gate works upon a wooden axle fixed across the box. The axle boxes are fitted at the sides 4 feet from the bottom of the box. The gate is strengthened with bands of 3 by 1 flat iron, the centre band extending 6 feet above the top of the gate, and containing a ring bolt. To this ring bolt is attached a rope working a shrieve erected on a small gallows not immediately over the gate. The rope is affixed to a flat piece of rock, or a piece of iron weighing about 125 lbs. This weight necessarily varies with the weight of the gate, and can be easily determined once the gate is in position. The sluice-box having been fixed, and the gate left open, the creek is once again diverted to flow through it. A dam is then built on each side of the sluice-box to the banks of the canyon. This completes the outfit, which is then ready to go into commission. Before, however, commencing work, the

owners of the " self shooter " proceed down the creek and select —as nearly as possible half a mile away—a natural hole in the creek and carefully clean it out. This serves as a " paddock " or final cleaning up spot. This done, the rope is attached to the ring bolt, the weight being sufficient to cause the gate to close. The water coming down the creek rapidly fills the reservoir made by the dam. In the instance under review fifteen minutes sufficed. When the water reached within 15 feet of the top of the gate the centre of gravity was shifted, and the gate swung open, closing again automatically as soon as nine-tenths of the water in the reservoir had been liberated. The tumultuous rush of water scoured the banks and bottom of the creek, exposing the bed rock, quicker than a " giant " directed by the most experienced hydraulic miner. The rush over, the bed of the creek is quickly examined (when I witnessed the operation, some 4 or 5 dwts. of coarse gold was obtained as a result). The return after each flush varies between ½ dwt. and a couple of ozs. The "paddock" clean-up, after a run of fourteen days, yielded 37⅓ ozs. The life of this particular "self shooter" was about 4½ months, after which it was taken down and re-built on another creek. The complete returns for the 4½ months ran into over 700 ozs. Considering the fact that all this ground had been worked over and over again, and even the proverbial Chinaman could not make tucker out of it, the result speaks volumes for the invention.

OBSERVATIONS IN GENERAL.

Under the title of " With the Junior Engineers in France," a series of fully illustrated articles by " Atlas," are appearing in " The Model Engineer and Electrician." The writer, whoever he may be, marshals his facts and views, both technical and social in quite an entertaining style.

* * * * * *

In continuation of our observations last month on the International Conference on Electrical Units and Standards, which is to open in London on the 12th October, we notice that the President of the Board of Trade has appointed Major W. A. J. O'Meara, R.E., C.M.G., to be an additional British delegate.

Our Vice-President, Dr. H. E. Armstrong, F.R.S., is announced to read a paper on "The Scientific Control of Fuel Supply" at the autumn meeting of the Iron and Steel Institute, to be held at Middlesbrough, on September 28th and following days, under the presidency of Sir Hugh Bell, Bart.

* * * * * *

Mr. Dugald Clerk, F.R.S. (Past-President), took as the subject of his Presidential Address before Section G of the British Association, "The Laws of Thermo-Dynamics as Applied to Heat Engines, and Considered in Relation to the work of Lord Kelvin"; and Dr. W. E. Lilly, our District Member of Council for Ireland, contributed a paper on "The Strength of Solid Round-Ended Columns."

* * * * * *

On the 14th October Mr. Clerk, in the rôle of President of the Incorporated Institution of Automobile Engineers, is to give an address on "Some Problems of the Motor Car."

* * * * * *

Members, especially those who witnessed his flight at Issy les Moulineaux during the Institution's Summer Meeting in France, will have read with much regret of the accident which befell M. Bleriot there last week when experimenting with his aeroplane. Happily, he was not injured.

* * * * * *

A propos of things aerial, the German Society of Engineers is to be congratulated on its action in contributing no less than £1,250 to the Zeppelin airship fund. It is noteworthy to add that the Society, which is the largest technical body in Germany, makes a special practice of identifying itself with movements tending to stimulate scientific progress, and for the carrying out of research work generally.

* * * * * *

As interesting to those engaged in the design and construction of small rock drills, a member in Johannesburg calls attention to the Transvaal Stope Drill Competition, which is to take place next year, two prizes of £4,000 and £1,000 respectively being offered. Entries must be deposited at the Transvaal Chambers of Mines, Johannesburg, on or before 31st December, and full particulars of the competition can be obtained from the London Office, 202 Salisbury House, Finsbury Circus, E.C.

FROM THE STARTING PLATFORM.

THE COMPARISON OF GENERATING PLANT.

Two qualities go to make up a good steam engine, firstly, it must never give trouble, secondly, it must not consume too much steam. Of course, there are other things to be considered when buying, such as first cost, space occupied, &c., &c., but when a plant is once installed the features first mentioned overshadow all others. Moreover, the order in which they have been placed above should be particularly noticed, although it is only intended to deal with the question of steam consumption now.

In practical work one always speaks of the efficiency of a generating unit in terms of the pounds of steam consumed per kilo-watt-hour. This is something which can be measured without great difficulty when the plant is tested, and is therefore convenient to be made the subject of a guarantee. But it does not tell the whole story. The conditions under which the plant is working must be stated before we can draw any useful conclusion from the steam consumption. It obviously makes a difference whether the engine or turbine is using high or low pressure steam, whether there is any superheat, or whether the vacuum is good or bad. To say that two generating sets are equally efficient because each uses say, 17 lbs. of steam per kilowatt hour is absurd by itself. One set may be working with steam at 120 lbs. pressure, a superheat of 100 degrees and a vacuum of 28½ inches, while the other uses saturated steam at 180 lbs. pressure and a 27 inch vacuum. Even if we are given these figures it is by no means easy to say, offhand, which plant is the more efficient, or how far from perfection either may be. Some of our members may not be able to work out the answer at all, and it is with the object of helping them that this note is being written. To others, no doubt the subject will seem elementary.

The best way to make a comparison between engines is to see how they each compare with a theoretically perfect engine working under the same respective conditions. To do this we must first know what such an ideal engine would do. It would obviously turn into work one hundred per cent. of all the heat energy liberated by the steam in expanding from the upper

pressure and temperature to the lower pressure and temperature. If one of our actual engines turns 50 per cent. of this heat into work, and the other turns 60 per cent. into work, we know at once how efficient each of them is, and how much better one is than the other.

The following formulas give the maximum quantity of heat that would be turned into work by a perfect engine, from every pound of steam passing through it. This amount of heat is called the "available heat," and is denoted by the letter u.

If the steam is dry to commence with, but not superheated, we have

$$u = H_1 - H_2 + T_2 (\phi_2 - \phi_1) \ldots\ldots\ldots\ldots (1),$$

whereas if the steam is initially superheated, the formula is (approximately)

$$u = H_1 - H_2 + T_2 (\phi_2 - \phi_1) + \frac{t}{2}\left(1 - \frac{T_2}{T_1 + 0{\cdot}5t}\right) \ldots (2),$$

in which formulas

u = the available heat (in B.Th.U.) in a pound of steam expanding between the upper and lower limits of pressure and temperature.

H_1 = the total heat (in B.Th.U.) of a pound of saturated steam at the higher pressure.

H_2 = the total heat (in B.Th.U.) of a pound of saturated steam at the lower pressure.

T_1 = the absolute temperature in degrees Fahr. of saturated steam at the higher pressure.

T_2 = the absolute temperature in degrees Fahr. of saturated steam at the lower pressure.

ϕ_1 = the total entropy at T_1.

ϕ_2 = the total entropy at T_2.

t = the amount of superheat in degrees Fahr.

The values of the total heat, temperature and entropy, for insertion in the above formulas are to be obtained from any good steam table, such as the one compiled by Sidney A. Reeve, and published at 1s. 6d. net., by Messrs. Macmillan and Co. The derivation of the formulas will be found in Messrs. Martin and Parsons' paper on the "Theory of the Steam Turbine (see *Journal*, Vol. XVII., page 447).

We are now in a position to obtain the thermodynamic efficiencies of the two plants mentioned above, and therefore to

make a rational comparison between the engines. Applying formula No. (2) to the conditions of the first mentioned engine we have

$$u = 1188{\cdot}2 - 1109{\cdot}6 + 552{\cdot}8\,(2{\cdot}0136 - 1{\cdot}5716) + 50\left(1 - \frac{552{\cdot}8}{810{\cdot}7 + 50}\right)$$
$$= 340{\cdot}8 \text{ B.Th.U per lb.}$$

Now a perfect engine (and generator) will produce one kilowatt for a consumption of $\frac{1000}{746} \times \frac{33{,}000 \times 60}{778} = 3412$ B.Th.U per hour. Therefore the plant we are considering, if perfect, would take $\frac{3412}{340{\cdot}8}$ = practically 10 lbs. of steam per kilowatt hour. But we have assumed that it has been found to take 17 lbs., so that its efficiency is $\frac{10}{17} = {\cdot}588$, or, as it is more usually expressed, the overall thermodynamic efficiency is 58·8 per cent. If we know the efficiency of the generator alone to be, say, 95 per cent., we get the efficiency of the engine alone to be ·58 ÷ ·95 = 61 per cent.

Taking the case of the second engine above-mentioned we have, using formula (1)

$$u = 1197{\cdot}1 - 1116{\cdot}8 + 576{\cdot}1\,(1{\cdot}9500 - 1{\cdot}5454)$$
$$= 313{\cdot}3 \text{ B.Th.U. per lb.}$$

The steam used by this engine thus has considerably less available heat than that supplied to the former engine. Hence the second engine must have a higher thermodynamic efficiency, since the steam consumption of the two is the same. A perfect plant would require $\frac{3412}{313{\cdot}3}$ or practically 10·8 lbs. of this steam per kilowatt hour, so that the overall efficiency, in this case, is $\frac{10{\cdot}8}{17}$ = 63½ per cent. Allowing, as before, 5 per cent. loss in the generator, we have the efficiency of the engine alone as 63·5 ÷ ·95 = nearly 67 per cent.

R. H. PARSONS.

CORRESPONDENCE.

SHIRE HIGHLANDS RAILWAY, NYASSALAND, B.C.A.

HERBERT J. BROCK (Member), writing from the Bridge Building Yard of the Shire Highlands Railway at Luchenza, makes reference to the notable event on 31st March last, of the

arrival at Blantyre, with His Excellency the Governor of Nyassaland, of the first passenger train on the first railway in Nyassaland (Shire Highlands Railway), and sends the two photographs reproduced on Plate 1 of the present issue.

FRANK J. G. GRAHAM (Member), a communication from whom on the work of bridging, for this Nyassaland Railway, the river Shire at Chiromo, appeared in *The Journal* for February last, page 197, has since sent the photographs (Plate 2) taken during the process of erection of the bridge, which is built on clusters of screw cylinders.

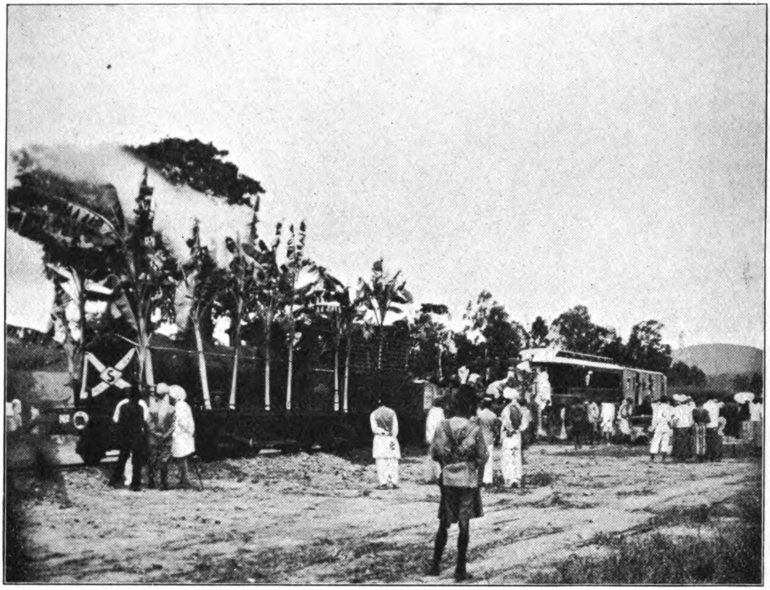
INDIAN IRRIGATION PUMPING PLANT.

WILLIAM P. ROBERTS (Member), in a letter from the address—Divi Pumping Project, Avinigudda P.O., Kistna District, India, under date June 15th, 1908, writes: "I came to this part of the country in the beginning of December last, having been engaged by the Government of Madras to take charge of the Divi Pumping Project Works, which were then practically completed, they having been able to irrigate about 12,000 acres during the previous season, which ended in October 1907. As it was wished to begin to get the benefit of the water as soon as possible, everything not of vital importance was left to be done last, such as finishing the supply channels, some of the bridges and embankments, parts of the buildings, and such details as extra fuel-oil storage tanks, wells, and pumps for fresh water supply, &c., &c., which have been dealt with during the last few months, during the off season when no irrigation is required.

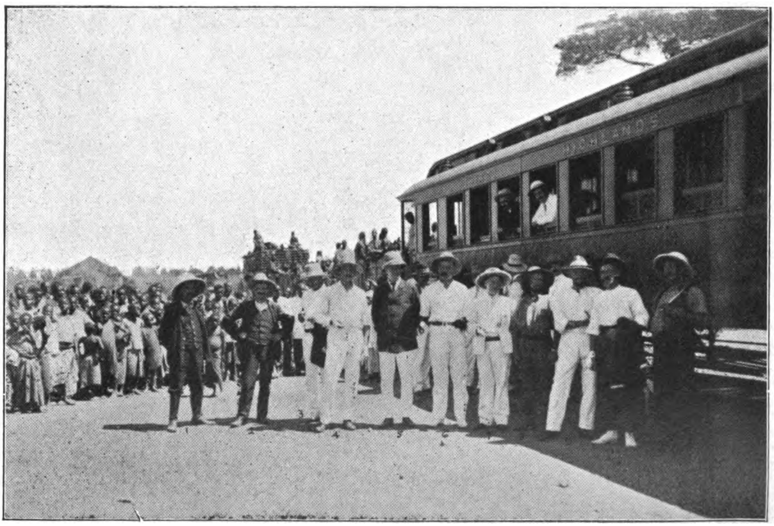
"The whole scheme may be briefly described as follows:—Divi Island lies in the mouth of the Kistna River, is about 25 miles long and triangular in shape, the base next the sea being about 20 miles wide. Some 60,000 acres could be cultivated if water were available, but hitherto only 12,000 acres have been under crops on the 'tank' system, *i.e.*, during high floods large tanks, some of them two miles in length, were filled by making a breach in the bank and letting in the river, and closing the opening again when the river fell. This was a most precarious method, as sometimes the floods were not high enough to fill the tanks, and at other periods they were so high that the old embankments were topped and the 'bunds' or banks round the tanks washed right away, in either of which cases there would

SHIRE HIGHLANDS RAILWAY CONSTRUCTION, B.C.A.

PLATE 1.

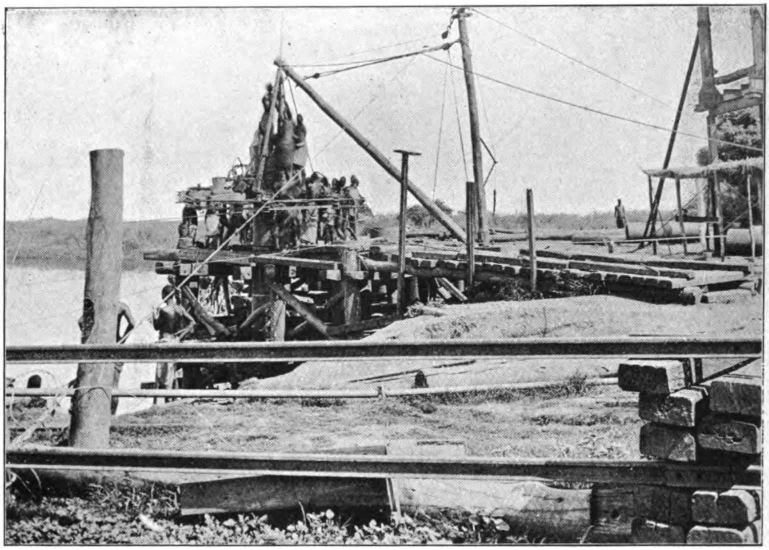


Arrival of First Passenger Train into Blantyre.

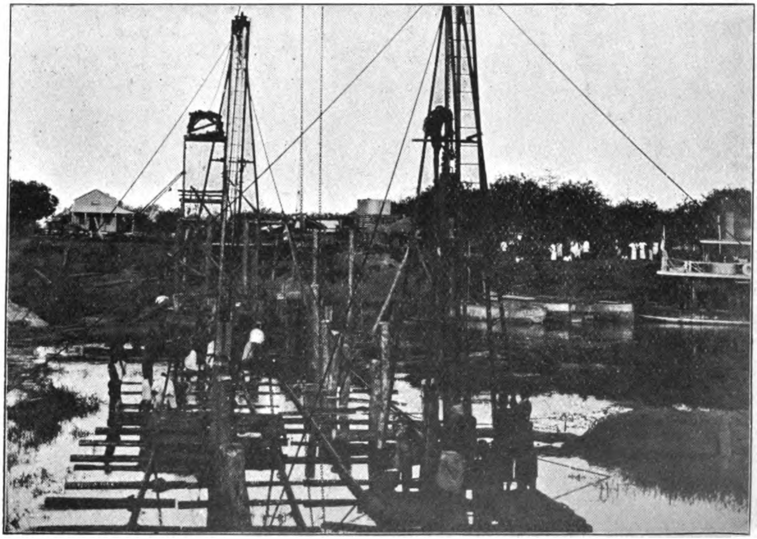


Railway Staff.

PLATE 2.



Erection of Bridge on Screw Cylinders over River Shire at Chiromo.



be no water stored for the dry season, and consequently no crops that year, resulting in great loss to the cultivators, and loss of revenue to the Government. It was finally decided to put down a pumping station at the up-stream apex of the island in accordance with plans prepared by Mr. R. N. H. Reid, M.Inst.C.E., of the P.W.D., and the work was begun after the subsidence of the floods in August, 1906, by which time the old tanks had been filled in the usual manner, and, as already stated, the plant was sufficiently advanced to permit of some pumping being done at the beginning of June, 1907, but soon after starting, the river rose sufficiently to afford a natural supply for four weeks, which gave opportunity to get things more finished in the power house. From the month of July pumping was continued as required, until the end of October, 1907, the end of the wet crop cultivation season in the district.

"All the buildings, earthwork and civil engineering work generally, was carried out departmentally under the supervision of the D.P.W.D. staff of engineers. The contract for the whole of the pumping installation and auxiliary machinery was placed with Messrs. James Simpson and Co., Ltd., of London, Newark and Calcutta. At the head works, in addition to the pumping station, there are four steel sluices 15 feet wide, and, so long as the river is high enough to maintain a supply of 5 feet 6 inches in the delivery channel, the water is taken direct, there being no need to pump. When the river falls, the pumps are started to maintain the full supply required. To supply the head sluices and the pump suction culverts there is a canal about half a mile long cut diagonally across the apex of the island, so that in the event of one branch of the river becoming silted up, a supply can be obtained from the other. The delivery channel feeds two main canals, 12 and 13½ miles in length, from which there are branch ditributaries, making a total length of about 90 miles in all, commanding from 50,000 to 60,000 acres of land suitable for cultivation, including the beds of the old tanks, which now will be available, as they will no longer be required as water storage reservoirs. The present population of the island is insufficient for working all this area, but it is anticipated that it will increase within a few seasons by immigration from neighbouring districts that are overcrowded, and that it will all be taken up in about three years time.

"The engine house, and all masonry works, are built of stone brought from quarries at Bezwada and Sutnapalli, 40 and 50 miles distant, there being none obtainable nearer, and the locally-made bricks are unsuitable for work in contact with water. In fact, the only materials obtainable on the site were sand and common bricks suitable for hearting works, such as filling up inside the four walls of the engine house, this being practically a solid block of brickwork and concrete 27 feet deep, with the suction culverts passing through it. The soil being all alluvial silt, the foundations are carried on caissons of brick-work with reinforced concrete curbs for the cutting edge, sunk until a bearing was obtained on a strata of coarse sand below. The sinking was done by a native method which probably most engineers at home have never heard of. Hand-power grabs were provided for sinking, but it was decided that it would be better to let the native workmen do it in their own manner, as it would be quicker, and more cylinders could be sunk at the same time. There is a class of men here known as 'wellsinkers,' who are good swimmers and divers, being able to keep under water a surprising length of time. They put a long iron rod down as a guide to show where to remove the material from; then one man dives down, and gripping the rod to steady himself, treads a closely woven basket down into the silty slurry and sand at the bottom, and fills it with his feet. To give him a purchase over his work, and weigh him down, a second man stands on his shoulders, and if the water be deep enough, a third man on the top of the second. When the bottom man has filled the basket, or wishes to come up, he pinches the big toe of the one above, who lets go, and they swim to surface. The coolies above then haul up the basket and empty it on to a platform, where the surplus water drains off and the material is then carried away in baskets to the spoil bank by ordinary coolies. Some of the cylinders were sunk in this manner in 14 feet of water. This is an example of the unusual methods of doing work that one comes across in out of the way parts of the world.

"The pumping installation consists of eight 39 inch centrifugal pumps, each capable of delivering 80 'cusecs' (cubic feet per second) against a head of 11 feet, or 60 'cusecs' on the maximum working lift of 16 feet. The pumps were made by James Simpson and Co., and give an efficiency of 70 per cent.

on a lift of 15 feet. Each is direct-coupled to a 160 B.H.P. double-cylinder Diesel engine running at 180 revolutions per minute, supplied by the Diesel Engine Co., Ltd., of London, and built by Carels Frères, of Ghent. These engines are of their latest type, fitted with Reavell air compressors in place of the two-stage plunger type compressors which were formerly used. There are also three 9 B.H.P. Hornsby Ackroyd oil engines, which are being run on the same kind of refuse fuel-oil as used for the Diesels, but of course not with so low a consumption per B.H.P. I think it may be admitted that there is no engine made that touches the Diesel on this point. These small engines are for driving the auxiliary machinery and the repair shop machine tools. The auxiliaries consists of two 4 inch Worthington centrifugal pumps for filling the overhead tank for cooling the water supply to the oil engines, two three-throw pumps for lifting the fuel-oil from the outside storage tanks to the overhead supply tank, two Worthington 12 inch by 10 inch air exhausting pumps for priming the large pumps, and two 7·6 K.W. dynamos by the General Electric Company, for the electric light and for supplying current for two motor-driven 3 inch Worthington centrifugal pumps in connection with a well outside. It will be noticed that the auxiliary plant is all in duplicate, and it is so arranged that either engine can drive any part of it or the workshop. Another very interesting feature is that for measuring the delivery from the pumps there are two 120 inch Venturi meters fitted with automatic recorders registering a week's supply on a chart. Each meter is capable of registering up to 2,250,000 cubic feet per hour. These are, I believe, the largest meters in the world.

"The reason that oil fuel was decided upon for the plant is that freight charges are so high that if coal were employed the cost of the power would be so much increased as to prevent the possibility of working the undertaking without a loss to the Government. The fuel oil is supplied by the Asiatic Petroleum Company, who land it at Madras and send it from there to Duggirala by rail in tank waggons. There it is discharged through a pipe line into tank barges which bring it another 45 miles by canal and river, and it is finally pumped from the barge to the storage tanks near the engine house, having come a total distance of about 500 miles by rail and water from the port it

was landed at. The pumping station being such a long distance from the nearest railway station gave the contractors a good deal of trouble in getting the machinery delivered, as the water in the canals was very low at the time of transport. They only just managed to get the last few boatloads through before the canals ran dry in the hot weather, and anything that was left had to be brought 40 miles by bullock cart over bad roads. We are a little better off now, as a new railway has been opened to Masulipatam, and there is a station within 23 miles.

"The installation, though not the largest pumping station that has ever been put down, is still well in the front rank, and is the largest that exists for irrigation purposes. The machinery has not yet been finally handed over to Government. Under their contract, Messrs. Simpson could be called upon to take the responsibility of the running of the plant for two years after the first six months working. For this they would be paid by Government and be provided with all oil, stores, and fuel required, and the contractors would provide a superintendent to take charge, and the rest of the staff, European and native, would be provided by Government. The Government have elected to exercise this right for a year at any rate, and so they have lent my services to the Contractors for that time to be their superintendent. I am thus acting in a dual capacity at present, being responsible to the contractors for everything in connection with the plant supplied by them, and for all other things, apart from the machinery itself, I am answerable to Government. It is rather a peculiar arrangement, but is answering all right so far, and I trust will continue to so long as it lasts. Under this arrangement I have now nothing to do with the work on the canals, &c., in the lower parts of the Island, which have been put in charge of a Sub-Engineer of the P.W.D.

"Though this place is rather out of the way and far from civilisation, it possesses some means of recreation. I have four European assistants, so an occasional game of tennis is possible. In the season there is snipe and duck shooting to be had close by, and there are wild geese on the river; in a neighbouring island there are black buck; the canals usually have plenty of fish in them, and there is good sailing on the river, and the country is suitable for riding, except in the floods. So when one gets time there is plenty of sport to be had.

PARA, BRAZIL.

JOHN McCLURE (Member), who left England last November, having been appointed Assistant Engineer on the New Harbour Works at Para, Brazil, in a letter received from him on the 22nd June writes:—"The city of Para is situated at the confluence of the Rio Guama and Rio Guajara, in one of the mouths of the River Amazon, south-east of the Island of Marajo, and about 80 miles from the sea. It is surrounded by dense forest and swamp, and, excepting a short metre gauge railway to Braganca, has no communication with the outside world other than by sea and up river. The whole district is very flat and low, the highest part of the city being only 20 feet above river level. The climate is very moist, with shade temperatures in the house of from 80° to 86° Fah., and one's clothes and boots grow a fine coating of mould if not sun-dried very frequently. A strong local breeze known as the 'Marajo,' blows every afternoon from the north-west, pleasantly tempering the great heat of the sun. The rainy season lasts about nine months, and is notable for the regularity of its heavy downpours. One can depend on a fine hot morning, with rain at three o'clock in the afternoon, lasting, with short intervals, well into the night.

"As a health resort, Para is not to be recommended. In addition to the usual malaria of the tropics, yellow fever is very prevalent, the death rate from that disease among Europeans being high. As a preventative, during the first few months of residence in Brazil, arsenic is being issued to the British staff on the port works (its use having been attended with beneficial results during an outbreak at New Orleans some years ago); whether its effect is good or not, it at least gives one something to pin one's faith to, which is a great thing under the circumstances. Adequate measures to exterminate the mosquito, of which we have many varieties, would do away entirely with yellow fever, but so far no steps have been taken to that end, though the Government has been approached on the subject.

"The cost of living here is very high, roughly, two and a half times the cost in England, consequently, any young engineer coming out should insist on a salary proportionate. The irreducible minimum suggested is £42 per month. The main trade of Para is in raw rubber, coffee and nuts; prosperity rising and falling with the demand for, and market price of, the rubber. Para and Manaos are the ports of transhipment

between up river boats and ocean steamers, and are very busy places. The Para port works, electric lighting and tramways, together with a large proportion of the shipping trade, are in British hands, and there will be unlimited scope for enterprise in the future as Brazil becomes opened up.

"There being abundance of local clay, the construction here is in brick and plaster, with red tiled roofs and hardwood floors. The forests abound in fine hardwood trees of great variety, but no attempt has been made in this district to form a logging industry, the difficulties of transport being great, as the logs will not float and rafts have to be made up with large quantities of lighter and inferior woods to give buoyancy to a few hardwood logs. In this connection, I noticed a few days ago a big sailing canoe come down river with two fine sticks of hardwood, lashed one on either side, in the water, and supported by hanging from the projecting ends of two pieces of timber laid across the boat over the gunwales.

BREWERY ENGINEERING.

The Nineteenth Visit of the Twenty-seventh Session took place on Thursday, 11th June, 1908, at 6.30 p.m., to Messrs. Taylor Walker and Co.'s Brewery, Church Row, Limehouse, by permission of Mr. R. Stewart Bradshaw, the attendance being 38.

The features of special interest pointed out to the members on proceeding through the brewery were as given in the subjoined notes. At the conclusion of the inspection, Mr. W. H. De Ritter expressed the Institution's acknowledgments of the courtesies which had been extended by Mr. Bradshaw and his assistants in connection with the occasion.

There are two mash-tuns, each of 100 quarters capacity, capable of turning out 1,200 barrels per day; one copper, containing 530 barrels, and two coppers, containing 300 barrels; Nalder's grinding machinery; two coolers, four Morton's refrigerators; pure air plant (McCardle); four fermenting vessels, of 180 barrels capacity each, and four of 500 barrels capacity each; eighteen skimming slates, of 180 barrels each, and four of 140 barrels each; eighteen slate yeast tanks; electrical cask elevators; two boilers (Galloway) 8 feet 6 inches

diameter by 30 feet long, and two boilers (Galloway) 7 feet 6 inches diameter by 28 feet long; two ammonia compressors (Linde) and refrigerating plant; two engines; cask washer; cooperage; wheelwrights' shop; clarifying room; pumps, cooler, refrigerator, filter; bottle washing and filling machinery; well pumps; stables for 150 horses. The brewery is lighted throughout by electricity, 3-wire system, 240 volts pressure; there are nineteen motors, working at 480 volts.

GAS STOVE MANUFACTURE.

The Thirty-Eighth Visit of the Twenty-seventh Session took place on Thursday afternoon, 16th July, 1908, to the Luton Works of Messrs. The Davis Gas Stove Company, the invitation being extended on this occasion to members' lady friends.

On arriving at Luton about 3.30 p.m., the party, 34 in number, were conveyed to the Works by brakes, kindly provided by the Company. Under the guidance of Mr. H. N. Davis, Managing Director, and Mr. Cyril Davis, they were conducted through the various departments by the route indicated in the following notes:—

General Offices. Drawing Office and Experimental Testing Room. Pattern Shop with machinery. Here patterns of every description are made in various metals. Pattern Stores. Moulding Shop, one of the largest in the country, contains upwards of 92,000 square feet. In this department castings are made for the building and general trade in addition to those used in the manufacture of gas cooking and heating apparatus. Furnaces, two in number, of American type. When working to their full capacity will each melt 18 tons of iron per hour. The blast is obtained from a No. 11½ Buffalo fan driven by a 75 h.p. electric motor. Furnace Platform (with motor house above). The pig iron and coke are brought up by hoist, and are here weighed and charged into the furnaces. The raw material or inwards siding is alongside, so that the furnaces are charged with as little handling as possible. Sand Mixing Shop, containing American sand mixing machines for dealing with the moulding and core sands. Dressing and Fettling Shop, containing rumblers, emery wheels, &c., for trimming the castings as they arrive from the moulding shop. Passing Shops. Here all the

castings are carefully examined and tested before being delivered to the various warehouses. Warehouse No. 1. Stalls or partitions are here provided for each of the hundreds of different castings used in connection with fitted goods, such as gas cooking and heating stoves, coal ranges, grates, mantelpieces, &c. Grinding Mill and Polishing Shop. Here the castings are ground and polished before going into the fitting shop. Berlin Black Shop where the castings for various goods are enamelled. Fitting Shop. This is divided into two portions, one for ranges, grates, &c., and the other for gas stoves. At the end of the gas stove portion of the fitting shop are two small gasometers, and the testing apparatus where all stoves are examined and tested before being passed into the stove warehouse. Warehouses Nos. 2 and 3. Here are stored all the finished goods, and adjoining is the outwards siding where goods are loaded into railway trucks ready for despatch. Warehouse No. 4. Here are stored all the unfitted castings for the building and general trade, such as rain-water goods, gratings, manhole covers, and frames, &c. This warehouse is situate between the moulding shop and outward siding, so that these goods can be loaded up for despatch with a minimum of handling into the same railway trucks as the fitted goods. General Fitting Shop. Here are fitted goods for the building and general trade, such as railings, sanitary goods, garden seats and tables, &c.

At the conclusion of the inspection of the Works the party were driven to the Red Lion Hotel for tea, by invitation of the Company, when, on behalf of the members, Mr. Geo. T. Bullock (Vice-Chairman), expressed their thanks for all that had been done to render the visit so interesting and enjoyable, Mr. H. N. Davis responding. It was intended to have concluded the programme with a drive in the evening, but owing to heavy rain this was abandoned, and the party returned from Luton by an earlier train.

"THE CONSTRUCTION OF THE FOUR PENNSYLVANIA RAILROAD TUNNELS UNDER THE EAST RIVER, NEW YORK."

Communicated by S. X. COMBER *(Member), of New York.*

The recent completion of the four tunnels under the East River between New York and Long Island City, for the Pennsylvania Railroad Company, marks an epoch in the history of tunnel building.

Four tunnels, each 23 feet in diameter and about 3,900 feet in length, have been driven simultaneously from eight headings, under compressed air at pressures varying from 28 to 38 lbs. per square inch. Included with the same contract are the four land tunnels on the Long Island side, which extend to East Avenue, Long Island City, a distance of about 2,000 feet from the Long Island City shafts. The entire contract embraced about 24,000 feet of tunnel, for the whole of which compressed air had to be used.

The entire contract was let to Messrs. S. Pearson and Son, Limited, of Westminster, of which Sir Weetman D. Pearson, Bart, M.P., is Chairman, and Mr. E. W. Moir, M.Inst.C.E., M.Am.Soc.C.E., is Director. For various reasons a separate company was formed to carry out the work, under the title of S. Pearson and Son, Incorporated; a corporation registered under the Laws of the State of New York. Of this latter company Sir Weetman Pearson is President, Mr. E. W. Moir, Vice-President, Mr. H. Japp, Managing Engineer, and our member, Mr. A. W. Manton, Deputy Managing Engineer. The English Company is simply a shareholder in the American concern.

The East River work and the Long Island City land tunnels form part of the great system of improvements of the Pennsylvania Railroad, extending from Harrison, near Newark, New Jersey, to Long Island, and including the line across the Hackensack meadows, the rock tunnels of Bergen Hill, the two tunnels under the Hudson River from New Jersey to New York, the immense new terminal in the centre of Manhattan Island, extending from Seventh to Ninth Avenues and from 31st to 33rd Streets and the two double-track land tunnels from the terminal site to the shore line of the East River, where connection is made with the East River tunnels about to be described.

In addition to this elaborate system of tunnels and the immense terminal, considerable surface work is being carried out on Long Island to provide for the handling, storing and making up of trains for the West; and in the construction of the New York Connecting Railroad, which, by means of a bridge across Hell Gate, will connect the Pennsylvania and Long Island Railroad with the New York, New Haven and Hartford Railroad.

The East River Tunnels extend from two shafts at First Avenue, New York, to two similar shafts at Borden Avenue, Long Island City, near the Terminal of the Long Island Railroad. Two of the lines in Manhattan are under 32nd Street and two under 33rd Street, converging towards the Long Island shore, the distance between the shafts being 225 feet on the New York side, and 103 feet on the Long Island side.

The two tubes, starting from the same shafts, are parallel and on 37 feet centres. Each tunnel measures 23 feet in external diameter, and is composed of cast-iron rings 30 inches long, each ring being divided into eleven 2,000 lb. segments about 6½ feet long, and a key segment 30 inches long located near the crown. All segments have a web of 1½ inch minimum thickness, and flanges 11 inches wide over all and about 2½ inches thick; those on the long sides being braced by transverse webs. The outer faces of all flanges are machined, and the joints are recessed 1½ inch for caulking. The rings are bolted together, as are the segments of a ring, to the adjoining segments, by 1½ inch bolts. A grout pipe is provided in the web of each segment, being normally closed by means of a screw plug, so that all cavities outside of the iron lining in the rock section can be pumped full of grout, and, where the tunnel is in soft material, a sufficient protecting coating forced to the outside.

The tunnels are lined with concrete, having a minimum thickness of 2 feet above the springing line and reducing the clear radius there to 9½ feet. Below the springing line, bench walls are carried up on each side, to contain the ducts for the power cables and lighting, telephone, telegraph wires, &c. These bench walls will also serve as a walk for the workmen engaged in the tunnels, and for passengers in case it should be necessary to allow them to leave the tunnels during a stoppage. At the deepest portion the base of the rail is about 90 feet below the

high-water line, and in one place the top of the tunnel comes within 8 feet of the bed of the river.

The work was started by sinking shaft linings, made of two shells, filled in between with concrete, and arranged so that they could be used as caissons if necessary. These shafts were 40 feet wide and 74 feet long, the steel and concrete lining in the Manhattan shafts extending to depths of 40 and 50 feet respectively in the South and North caissons, and 84 feet in both of the caissons at Long Island City. On the Manhattan side they were sunk without air-pressure, and on reaching rock the excavation continued in the open, the walls being faced with a lining of concrete. On the Long Island side, however, they were sunk under pressure, one of the shafts being located in a slip having 16 feet of water., The caisson for the latter was built on a falsework of piles, and lowered to the bottom by means of jacks. When the proper depth was reached the bottom rock was waterproofed and concreted, and the roof of the working chamber removed. Inside of these shafts the tunnel shields were erected, and when completed, were pushed out of the shafts through the circular drums in the river side. The circular drums were temporarily closed by movable bulkheads until all was ready to start the shields.

All of the eight shields used for the subaqueous work and the two shields for the land tunnels in Long Island City were duplicates in design save for the fact that those for the land tunnels were built somewhat lighter than those for the river work. In outside dimensions they were 23 feet 6½ inches diameter, and 18 feet 6 inches long, weighing about 542,000 lbs. each. They were divided across the section by two horizontal platforms, one 8 feet and the other 15 feet above the lower edge of the shield, and by two vertical diaphragms parallel with the axis of the tunnel, thus dividing the interior of the shield into nine separate compartments. Transverse, *i.e.* perpendicular to the axis of the tunnel were two vertical bulkheads, 2½ feet apart, made with heavy angle-iron frames and ½ inch steel plates. In front of the forward bulkhead these nine compartments or chambers could be closed with vertical transverse adjustable shutters, movable backward and forward by powerful screws that enabled them to be pushed up against the face of the earth in front of the shield, and likewise to be withdrawn from the

face so as to clear it when the shield was advanced. The men worked in front of the forward bulkhead, with or without the protection of the shutters, two of them being stationed in each of the three large chambers. When the shutters were in service, small apertures were opened or closed by means of sliding doors, leaving holes of small area through which, under the worst conditions, the soft mud and sand could be excavated. The spoil was shovelled up and deposited in inclined chutes, passing through both diaphragms, and being delivered to the rear of the shield, where it was shovelled into dump cars and hauled by cable traction to the air-locks. When the ground was not bad the men attacked the whole face of the heading corresponding with each compartment of the shield.

Provision was made on the upper half of the shield for a movable semi-circular hood, 6 feet long, forming an extension of the shield, so as to afford protection from soft upper stratum when it was necessary to excavate rock below it. The material encountered in the work included mud, quicksand, solid rock, rock and sand, rock and boulders, and sand and boulders, offering a very great variety of problems in the method of handling the work. The difference in the water pressure at the crown and at the bottom of the shield naturally introduced quite a problem in balancing the air-pressure against the column of water, particularly in the soft material which was encountered through so much of the length. When the pressure was just sufficiently high to keep the upper half of the face dry the lower half would be very fluid, making it extremely difficult to prevent the shield from sinking. Despite this difficulty, the grade was maintained with remarkable precision, as was shown by the excellent checks when the four tunnels met under the bed of the river. Another difficulty in connection with the proper regulation of the air-pressures within the tunnels arose from the small depth of the cover between the top of the tunnel and the river bed, increasing the possibility of blow-outs if the pressure was raised, so as to drive out the water and dry the bottom of the face.

The cast-iron lining was put in place by two independent hydraulic erectors attached to the rear bulkhead of the shield, and entirely within the tail-piece. These erectors each had two hydraulic cylinders, one of which was used for raising and lowering the segments of the ring, and the other for turning them

through any angle and placing them at the proper points on the circumference. The latter movement was accomplished by a toothed rack which operated a pinion on the arm supporting the other cylinder. This double motion allowed the erector to take a segment from the car on which it was brought into the tunnel, revolve it to the proper angle, and then extend it radially and hold it in position until it was bolted to the adjoining segments.

The power for advancing the shields was obtained through 27 hydraulic jacks, each 9 inches in diameter, operated with a water pressure of 6,000 lbs. per square inch, thus affording a total pressure of about 5,000 tons. Each forward movement of the shield amounted to 30 inches, the length of one ring. Immediately following the shield, and pulled along by it, was a platform upon which was mounted the apparatus for mixing and ejecting the grout to the outside of the cast iron lining. It consisted of a motor-driven grout mixer and a suitable pump. This platform was also used by the men who caulked the joints between the various rings and the segments. A cable haulage system was used for operating cars over a double track which was kept close up to the shield, for the delivery of the iron segments, cement and other materials. In order to avoid constant change in the length of the cable as the shield was pushed forward, a system of counterweights was adopted which took up a considerable amount of slack, and made a change in the length of the cable necessary only at considerable intervals.

Extending from the shield back throughout the entire length of the tunnel was an elevated gangway carried above the springing line and providing a safety and emergency exit in case the tunnel should be flooded while diving operations were in progress. Forming an essential part of this safety exit scheme were steel diaphragms, or safety screens as they are called, which were built transversely across the upper half of the tunnel at convenient intervals. In case the tunnel was flooded, the air between these screens would be trapped on the principle of the diving bell, and security afforded to those upon the elevated passageway, which was well above the bottom of the screens.

When the work was started there was naturally but one bulkhead between the outside air and the shields, but as the tunnels progressed a second bulkhead was put in and fitted with airlocks, thus allowing the full air-pressure to be attained through

the medium of two locks instead of one. In the lock located at the bottom of the shaft about half of the pressure, approximately 15 lbs., was put on, and the increase to the total pressure was maintained only between the second bulkhead and the working face where excavation was in progress. These bulkheads were of massive concrete, 10 feet thick, and contained three air-locks, two side by side at the bottom with their floors at the level of the spoil tracks, and the third in the upper half of the circular section. The two lower locks were used for handling materials, while the upper one, called the emergency lock, was reserved for the use of the men, and had its floor at the level of the suspended gangway above referred to. Except during the period when men were going through the lock, the door opening to the inside of the tunnel was always kept open, so as to cause no delay should any accident require the immediate use of the lock for exit from the tunnel.

On account of the great number of men constantly employed in the compressed air in the various headings, exceptional precautions were taken to insure their safety, and to give them proper attention in case of attacks of the "Bends" or caisson disease. A medical staff was in constant attendance at both shafts day and night, and six hospital or medical locks were provided. These medical locks are provided with a chronometer, gauges, and other apparatus for adjusting and regulating the pressure to suit the case of the particular patient under treatment. The hospital or medical locks each have two compartments, so that when a patient is under treatment in the inner lock, attendants and physicians can enter and leave without changing the pressure to which the patient is subjected. Each applicant for work under pressure received a thorough physical examination and a complete record was made of his condition and of other facts which it was desirable should be permanently recorded. The applicant was then subjected to a preliminary test in the air pressure, and if this test and the examination proved satisfactory, he was accepted.

The efficient handling of a work of this character necessarily required an extensive surface plant for the hoisting and disposal of excavated material, storage of cement, cast-iron segments, tools and various supplies, locker-rooms and facilities for the comfort of the employees, and power houses for the air-com-

pressors and electric power plant. Two large plants were erected by the contractors, one on the Manhattan or New York side of the river, and the other on the Long Island side. The power house on the New York side contains seven 16 and 34 inch by 42 inch Corliss duplex compound air-compressors of Ingersoll-Sergeant make for supplying air to the tunnels, two high-pressure air compressors of the same make for supplying the air-drills, and high-pressure hydraulic pumps for supplying power to operate the hydraulic jacks for advancing the shields. The rated capacity of low-pressure air is 35,000 cubic feet of free air per minute. The equipment on the Long Island side is similar to that on the Manhattan side.

The contractors celebrated the occasion of the meeting of the tubes by a dinner, which they gave at the famous Sherry's, on Fifth Avenue, New York. The Directors of the Pennsylvania Railroad Company were present, and there were many notable visitors, including Charles M. Jacobs, Chief Engineer of the four tunnels built under the Hudson River for the Hudson and Manhattan Railroad Company; M. J. Degon, who built the two Belmont Tunnels under the East River from East 42nd Street, New York, to Van Alst Avenue in the Borough of Queens; and many other prominent engineers and contractors. The Engineering Staff, Assistant Engineers, Superintendents, Assistant Superintendents, Shield Inspectors, &c., were also present. The toastmaster was Mr. E. W. Moir. Before his departure for Europe on the morning following the banquet, Mr. Moir was presented with a handsome model of a medical air lock as used on the works. A silver plate bore the inscription: "Presented to Mr. E. W. Moir, maker of the first medical air-lock, used on the old Hudson Tunnel, New York, 1889, by grateful workers in the P. R. R. East River Tunnels, March, 1908."

"CHINESE NATIVE LABOUR IN THE HONG KONG DISTRICT,"

By ROBERT BAKER, of Kowloon (Member).

When the writer first came to Hong Kong he was most disappointed in the local labour. During the six years previously spent in Malay he had formed a very high opinion of the Chinese, and he did not wish for better workmen. He may have been particularly fortunate in getting good men, notwithstanding the fact that he engaged everybody who offered themselves who looked as if they would be workers, or he may have been influenced, unconsciously, by the comparison between the Chinaman and the Malay, to whom all work is undignified. The European opinion in the district of Hong Kong is that the labour obtainable here is inferior to that in any other part of China.

There is without doubt a vast difference between native and immigrant labour. The Chinaman going abroad without his women-folk (always on the first trip, and usually on others) is entirely dependent upon his own resources. He soon realises the necessity of working in order that he may eat. His previously restricted mental outlook is broadened, and he finds that the outer world is more extensive than he had thought, that his own native land is neither all-powerful nor perfect, and that there are other and better ways of doing things than in the manner to which he has become accustomed. He very quickly becomes quite a different man to his stay-at-home brother, and is distinguishable by being energetic, intelligent, hardworking, untiring, and happy.

As regards native labour a great deal naturally depends upon whether workmen are needed for similar work to that involved in the various native industries. If so, the results obtained by the employment of Chinese may be considered excellent, or at all events, satisfactory. If, however, the industry for which they are required is something new to the country, there is little doubt that a very adverse opinion would be formed, owing to the fact that the local workmen will require to be taught—a difficult thing in itself, but all the more so because the Chinese do not readily become accustomed to European methods or adept with European tools.

The unskilled labourer is, as a general rule, ignorant, lazy, happy-go-lucky, and frequently stupid. Patience is necessary on the part of supervisors. An unskilled coolie needs to be shown how to do a thing day after day, as until he has tried all the wrong ways nothing seemingly will induce him to do it the right way. Haste or harshness are useless. Force is worse than useless. The man is in his own country, and therefore to a certain extent independent. If he does not like his work or his master (providing his pay is not much in arrear) off he goes to stay with some relative or other until he finds some other work. Work is abundant and relatives plentiful, so that he can afford to suit the circumstances to himself and not himself to the circumstances.

Fitters.—The Chinese craftsmen on the other hand are not so unsatisfactory. Engineers' fitters are probably the most intelligent artisans to be found on public works. Unlike the English fitter, who is usually trained in some large works and employed year-and-year in the same department, probably at the same class of work, and frequently at the same bench, tool or machine, the Chinese fitter has received invariably a good all-round training, making him both ingenious and self-reliant. He may not be able to boast of any great knowledge of any particular metal, tool, or class of work, but as an all-round man he usually gives satisfaction. It is to the ship-repairing and ship-building yards that the credit is mainly due, as in such establishments opportunities are given him to learn the use of every kind of European tool and machine, of which he quickly takes advantage.

The average wages paid to Chinese fitters are :—

	Foreman.	*Journeyman.*	*Labourer.*
Per month, Chinese dollars	35.0 to 60.0	15.0 to 24.0	10.0 to 12.0
Per day ,, ,,	1.20 to 2.0	0.50 to 0.80	0.33 to 0.40
Per hour ,, ,,	0.15	0.07	0.04

The exchange value of the Chinese dollar fluctuates greatly, but averages two shillings.

All wages vary according to the locality and distance from headquarters, and whether or not housing accommodation is provided. The hourly rates are those usually paid in the workshops. For the monthly wage every day in the week is worked.

Blacksmiths.—The Chinese blacksmith has often had a training similar to the fitter's, and such a man is very useful for shop work. For general smith work, such as is usually required at public works, the native-trained man is perhaps a better workman, as with no knowledge of the steam hammer, fan-blower, or pneumatic rivetter, he is capable of making good use of his forge for general work. He takes readily enough to leather bellows and hand fans for his forge, but much prefers his own blast, which is obtained from a wooden box or cylinder, often made from an old tree trunk, fitted with a piston stuffed with feathers and a valve at either end. This arrangement acts exactly like a steam cylinder, the exhaust being the blast. The blasts for the Chinese tin-smelting furnaces in Malay are of the same description but larger. The hammer man who works the piston rod walks backwards and forwards a distance of 8 or 10 feet, alternately pushing and pulling the piston rod. With this device a very regular blast, and any required heat can be obtained.

For large forgings or welds a native smith often has as many as three hammermen, and although at first sight this arrangement would not appear to be economical, yet labour is very cheap, while fuel is expensive, and it is found advisable to get the maximum number of blows upon the work for the least expense in heating. Very few employers of labour in China recognise this fact sufficiently, seldom allowing a smith more than one striker on day work, and therefore incurring greater expense in the long run.

The average wages paid to smiths are:—

	Foreman Blacksmith.	*Smith.*	*Striker.*
Per month, Chinese dollars	30.0 to 45.0		
Per day ,, ,,	1.0 to 1.50	0.60 to 0.75	0.33 to 0.50
Per hour ,, ,,	0.12	0.08	0.05 to 0.06

Carpenters.—Chinese carpenters seldom specialise, the average man employed on public works possessing all-round capabilities. It is true that some men prefer to act as sawyers, while others take to joinery work, and the branch trades of boat-building, coopering, box-making, &c., but the great bulk of Chinese carpenters act as general men, able to carry out all kinds of operations involved in wood-working. Considering the

few tools the Chinese carpenter uses, he is a man of vast resources. A European carpenter is recognised by his saw, while a Chinese carpenter uses his axe. The axe acts as a universal tool. It is wedge shaped, straight edged and straight shafted. It weighs from 2 to 3 lbs., and no carpenter, from a pile driver to a cabinet maker, is without one. His equipment also includes a string box containing a string with a small lead weight attached to one end. At the near end of the box an ink pad is provided, and the string after passing over this pad is wound round a reel fitted with a crank handle at the other end of the box. The string is then used in the same way as a European carpenter uses his chalk-line. His further tools consist of a frame saw (a hand or tenon saw is never seen), a plane or two, the boxes of which are probably home-made and the plane irons wedged in position with an iron staple; an awl with a special kind of two-winged bit worked with a bow; one or two chisels, the handles of which instead of being driven on to a tang are fitted into a shoe similar to a European garden rake or hoe. Any further tools that may be required to carry out the work are made on the spot. A square is rarely included, while a Chinese foot rule of 10 inches is about 17½ inches long!

With his axe the Chinese carpenter takes off rough edges, or chops a knot, so that two or three strokes with the plane finishes the surface. The axe is employed also as a mallet and hammer. His bench is always home-made and takes the form of a trestle, a plank about 5 to 6 feet long, 7 inches wide by 2 inches thick being fixed so that the back end stands about 21 inches from the ground, while the front end is only about 15 inches high. A couple of wooden stops of about 1¼ inch square are often fixed in the form of a V so as to support a plank on edge. The Chinese carpenter always sits on his bench or on his work when using his plane while he puts one or both his feet on the timber when using the saw. If rebating planes, ploughs or beaders are necessary he will make them himself. It is very rarely that any European tool is to be found in his tool bag nor will he use one if he can help it.

The sawyer is a patient and persevering man. Native timber is seldom more than 10 inches in diameter, and, being a light coarse grained pine with very little "nature," it saws easily. The sawyer's principal work, however, is sawing hewn baulks

of foreign hard wood, often as large as 42 inches square and from 14 to 20 feet long. These baulks are floated and towed to the shore to a suitable site, sometimes below high water mark, and often quite close to the place where they will be eventually utilised. They are then hauled on rollers, with block and tackle, or levers. The sawyer then takes charge and raises one end of the baulk by a series of levering operations until he can build a trestle under it about half way along. If the baulk be very heavy he will construct a trestle alongside on inclining ground so that the baulk can be rolled on to the trestle until the end is sufficiently high above the ground to allow room for sawing.

The saw is merely a huge frame saw, but instead of the usual cord or gut, an iron rod with rings at either end and wedges are employed. The blade is often made from bedstead iron, the teeth being cut by the sawyer himself, and "pitched" according to the hardness of the timber. Working without assistance, he marks a string line and patiently cuts through the log as far as the trestle, when, by overbalancing the baulk, he is able to finish the job by sawing down from the other end. He may be able to get but six or seven inches of movement on his saw during the deepest cut, and the work may take days to complete one cut, yet he will plod doggedly on from sunrise to sunset, often in the broiling sun, but never in the rain, with a persistence worthy of emulation. The two slabs are afterwards cut to the required scantlings in an exactly similar manner.

The pay for Chinese carpenters averages :—

	Foreman.	*Carpenter.*
Per month, Chinese dollars	35 to 60	
Per day ,, ,,	1.20 to 2.0	0.50 to 0.65
Per hour ,, ,,		0.06 to 0.07

Painters.—Chinese painters prefer to use a bit of rag or waste rather than a brush. The operation is quicker and does not need so much paint to cover a definite area, but it is a careless method and open to many objections. Brushes are only used for narrow lines or lettering, and are made in the form of a box packed with bristles, the sides of the box being cut away as the bristles wear.

Stonemasons.—Stonemasons are probably the most independent and most conservative class of skilled Chinese

artizans, and the masons' guild is quite a strong and influential society. Granite abounds in the colony of Hong Kong, both on the mainland and adjacent islands, usually in the form of huge boulders. Granite masonry is comparatively cheap, and the quarrymen and stonemasons are plentiful enough, but throughout all grades, although clever and capable, the majority of workmen are too apathetic to put their best efforts into their work. The methods adopted by the quarrymen are interesting. Of course, with the exception of the occasional use of a square or a pair of dividers, not a single European tool is used. Small light drills are made from iron rod, bitted and tipped with steel by special blacksmiths, who work solely for the trade. These drills are never touched with a file or grind-stone, but appear to wear better than European-made drills. The blacksmiths work only with a tapering round pointed hammer, using a piece of granite for an anvil.

All the hammers used by the masons on a tool are of round form, about $1\frac{3}{4}$ to 2 inches in thickness, and from 4 to 6 inches in diameter. Repeated use flattens and dents first one part and then another, until eventually the hammers take the appearance of a nut from a $1\frac{1}{2}$ to 2 inch bolt.

Huge boulders are split with wonderful skill by means of a single hole and one charge of native powder. Stones are split into required sizes by rows of shallow punched holes and wedges bound in a strand of oakum to afford a grip, no feather being used. Slabs of stone over 20 feet long by 3 feet by 6 or 8 inches are not at all uncommon, quarried in this manner for doorposts, lintels, verandah copings, &c. The spalling hammer used for driving the wedges is from 10 to 20 lbs. in weight, and tapers from a flat nose at the small end to the other, in which a light and flexible shaft is fitted. The handling and transport of big stones is particularly clever. The smaller stones are suspended in one or two rope slings from a pole carried by two, three or four men. Larger ones are lashed to a stout pole which is then suspended from and lifted by other cross poles, under which the men place their shoulders, and walk off with a heavy stone in a surprising manner.

Most quarries are worked upwards, and in many, a narrow slide is made down from the working face to some open space where the stone may be dressed. This slide is plastered with

stiff slippery clay, and kept well wetted. Thus huge stones may be tilted on to a small board, often not larger than 18 inches by 9 inches by 3 inches with rounded edges, and, with the aid of ropes and poles, may be slid or dragged to any distance at almost any pace.

The stone-dresser works up his stone much in the same way as the sawyer deals with his timber baulk, using a string box, hammer, and punches only. The punches are often made from old bolts, tipped with steel—the signs of the original screw thread may be traced distinctly very frequently. They are all of one shape. A square or Chinese foot rule are rarely to be seen; very few men consider them to be necessary. The string box, hammer and punches suffice to finish the stone off to smooth punching, but for hammer-dressing a punch is bound in a handle made of flexible wood or rattan, bent double round the punch and leaving about 9 or 10 inches as a gripping space for both hands. Boys are usually employed for this kind of work.

Practically all such work is by the piece. As a comparative example of ruling rates, stone quarried square, 3 feet by 1 foot by 1 foot, rock faced and rough punched for 9 inches on beds and joints ready for laying, stacked at quarry, is paid for at the rate of 14 cents. per cubic foot, headers and stretchers alike, irrespective of quarry dues. Similar work laid in cement mortar and pointed, excluding all charges, facework only, taken at an average of 16 inches thick, costs from 60 to 80 cents. per cubic foot according to the distance from the nearest quarry.

The building mason will always lay his stone dry at first, as it often wants trimming to fit. He will then upset it, lay his mortar joint, placing small spalls at the corners, unless very carefully watched, and then drop his stone again on the joint, slewing it into position with small pinch bars and afterwards grouting up the vertical joints, using a small sword-shaped piece of bamboo. The trowels are always battens of wood roughly hewn to shape. In archwork the longitudinal joints are placed over a lagging, the ends are pointed, and the bed grouted up from the extrados.

The Chinese masons are paid on an average:—

	Foreman.	*Mason.*	*Bricklayer.*
Per day, Chinese dollars	1.0 to 1.50		
Per hour ,, ,,		.07 to .09	.06 to .07

Bricks are carried by women, 18 to 24 at a time, in two light bamboo hoops attached to either end of a shoulder-stick. Mortar is carried in small shallow wooden buckets, usually four at a time, suspended in a similar manner. Although sand is plentiful it is never used for mortar in this district, the shell or coral lime being mixed with red earth.

A Chinese bricklayer never uses a metal trowel, but a wooden batten of similar shape, though smaller, to that used by th stone masons. This and a piece of string completes the outfit. He is not very particular about bond, and requires to be forced to wet his bricks before laying them, while he is so extremely economical with the mortar that, unless well supervised, his work is usually hollow. This place is notorious for bad brickwork, and when a house cracks or collapses (quite a common occurrence) it is explained as being due to some typhoon which at some time or other had strained that particular house.

The Bamboo Man.—No description of labour would be complete without a reference to the bamboo man. In almost every contract his work is a distinct but very essential trade. The bamboo man makes all the mat-sheds or temporary quarters for coolies, temporary bungalows for the supervising staff, cement sheds, stones and workshops, all scaffolding, temporary bridges, piers, &c., &c.

The only tools that he makes use of are a sort of pruning knife, and a small frame saw. The whole of his work is fastened together with bamboo lashing strings, about eight feet long, split from poles. Very rarely galvanised iron binding wire is used, and usually only when a scaffolding may be required to last for a number of years.

All framework, whether for houses or any other purpose, is made of bamboo or China fir poles from 2½ inches to 5 inches diameter, the cross bracing being made from 2 inch to 3 inch poles. The ends of the lashing strings at all joints are twisted and tucked in the same manner as straw bands round a sheaf of corn. In Hong Kong it is not at all uncommon to see stones up to and over one ton weight raised some thirty to forty feet on such apparently flimsy scaffolding.

The flooring to bungalows, &c., is made of ½ inch planks of China fir laced on to the floor joists with bamboo lashing, while the sides and roof are thatched with leaves of the fan palm

laced up into lengths, lashed in turn to the building with bamboo. Such buildings, with doors and windows of similar construction, would cost from 16 to 18 Chinese dollars per square of ground area, if bought outright, but the bamboo man prefers to hire his work out for fixed periods, during which he undertakes to keep it in proper repair. The value of this system will be appreciated by considering the scaffolding for the construction for a high chimney stack or a large building on which work may be unavoidably delayed for some time. Bamboo lashings sometimes rot, or poles get broken, and the responsibility taken by the bamboo man saves endless trouble and expense on the part of the builder or contractor, who otherwise would have to keep bamboo men and material always on the spot, ready for such emergencies.

With regard to labour on such light scaffolding, it may be of interest to add that bricklayers, plasterers, rivetters, painters, &c., are quite content to work on the bare cross poles. They require no guard rails. There is no Workmens' Compensation Act, nor is one needed. The men cling to the bamboos with their legs and toes, both hands being free, and such workers as bricklayers, who require some form of platform, fix a temporary one which is carried up with them as the job progresses, while an inclined zig-zag gangway is built, inside or outside, for the material road, no ladders being necessary. A brick double-storied detached European villa may be scaffolded, cleaned, colour washed, the pointing picked out in colours and all outside repairs and pointing done and the scaffolding removed again in four days—so quickly is the scaffolding executed. Such a feat is, of course, exceptional, for the Chinaman is not noted for hurrying. The speed at which bamboo work may be done is most noticeable when one sees temporary theatres, about 150 feet square and about 150 feet in height, capable of holding thousands of spectators, run up and completed in a few days by a dozen or so bamboo men, while after use, the whole structure will vanish again in a day or so. One or two bamboo men are sometimes kept on works where a large number of baskets are in use, simply for repair work. Wages would run from 40 to 70 cents. per day.

(*To be continued.*)

MEMOIRS.

Lord Kelvin (William Thomson) was the son of Dr. James Kelvin, and was born at Belfast, in June, 1824. The father himself was a man of note who, by assiduous studies and hard work, attained a position of considerable distinction. Son of a small farmer, he chose for himself the profession of schoolmaster, and for some time taught in a school at Ballinahinch, Co. Down. He was also a teacher of mathematics at the Royal Academical Institute at Belfast. In 1832, that is to say when his son William was about eight years old, he was created Professor of Mathematics at Glasgow University, where part of his studies had been carried out, and he and his family removed there. He himself undertook the first education of his sons, and how well this must have been done is evidenced by the fact that in 1834, when just over ten years old, young William matriculated as a student of the College. Here his progress was rapid, and he won many prizes, including the University prize for an essay on the "Figure of the Earth," which he obtained in 1838, being then only fourteen. At an age which now-a-days would be considered very much too young, namely, fifteen, he went up to Cambridge, being entered at St. Peter's College. He did not take his degree until 1845, when, at the age of twenty-one, but when he did take it he was placed second wrangler. There is some report that had he had more facility in writing he might have been Senior, but we do not know how much, if any, truth there is in this. However, if not Senior, he was Smith's Prizeman, which is by many considered the more noteworthy achievement. We are, unfortunately, not in possession of much detail as to his college life, but what is known is that he was by no means wholly a bookworm. He enjoyed himself vastly there, rowing in his college boat when it was second on the river in the May races, and winning the Colquhoun Sculls in a skiff, so it is said, of his own design. He was also made President of the Cambridge Musical Society, music being one of his great delights.

Shortly after taking his degree he was made a Fellow of his College. Later on, on the occasion of his marriage, he, of course, had to resign this post, for at that time Fellows could not marry and still retain their Fellowship. However, the distinction was re-conferred on him in 1872. This will tend to show what was thought of him at the University, but perhaps

this is more strongly brought out by what one of his tutors wrote about him when it was proposed to appoint him Professor of Natural Philosophy at the Glasgow University. He said that young Thomson was considered by those best able to judge as being the foremost man of science among the rising generation.

And so, while still only twenty-two years of age, he was, in 1846, appointed to this professorship, and went back to Glasgow, but in the meanwhile he had most usefully spent some time studying in Paris, under Regnault. Before this period he had written and published a number of abstruse papers. One of these was a defence of certain theorems in Fourier's Harmonic Analysis, and another "On the Uniform Motion of Heat in Homogeneous Solid Bodies, and its connection with the Mathematical Theory of Electricity." In a way therefore, young Thomson was already famous when he was but twenty-two; indeed the very fact that he was given the Professorship shows that in actual truth he must have been famous. His appointment reflects great credit on the discernment of those responsible for his choice, for at Glasgow he remained, despite the many temptations which must have assailed him to try his fortunes—which, with his ability, were assured beforehand—in the Metropolis. There are at the University two whole generations of students who have passed through his hands, and if we may judge by the reports of all those whom we have met, and who have sat under him, he must have won the love of all. Whether he loved all of them—for many were troublesome and boisterous at times—is quite another matter.

Great as was the work which Lord Kelvin carried out as a teacher of students, the world is probably more in his debt in other directions. There has possibly been no other man who has made so many inventions, so widely different in their character. One of the foremost of these is that which made long-distance cable telegraphy a commercial possibility, namely, the syphon recorder. He became interested in cable work almost, if not quite, from its very commencement, and made a deep investigation into the question of retardation of signals, and the effects of capacity and induction. As a result, he was able by mathematical methods to design cables most suited to their special work, but even when these were constructed it was impossible to use long cables with commercial efficiency. It is characteristic

of the man that, having realised a difficulty, he set himself to overcome it. The difficulty in this case—to leave out all technical description—was that the signals sent from one end of a cable, if despatched too fast, got mixed up with those which had gone before them, so that it was impracticable to send more than a few signals a minute, sometimes not even that. His first attempt at improvement was the mirror galvanometer. This delicate apparatus consisted of a minute circular mirror, with small steel magnets fixed to its back, suspended by a silk fibre inside a coil of wire. The magnets—and hence the mirror—were deflected either to one side or the other, according as the current sent was in one direction or the other. A beam of light was projected on to the mirror, and the signals sent might be read by watching the movements of the reflected spot of light.

This apparatus, beautiful as its action was, had this defect, that no record was left. The whole system depended on the fact that the operator must keep his eye resolutely fixed upon the spot of light. This invention was patented in 1858. It was nine years later that the greater discovery of the syphon recorder was achieved. Several other instruments in connection with telegraphy had been patented in the meanwhile in conjunction with Varley and Fleming Jenkin.

Practically speaking, the syphon recorder is now universally used with all long-distance cables. Like many other really great inventions, it is wonderfully simple. It consists of a small rectangular coil suspended between the poles of a magnet. At first an electro magnet was used, but now-a-days permanent magnets are employed. The current from the cable is led through this coil, and it accordingly moves round its axis in the magnetic field either one way or the other. Moving with it is a small glass syphon, one end of which dips into an ink reservoir and the other end nearly touches a moving strip of paper. By one of several means, however, the ink is made to issue from the syphon on to the paper, and hence, as the coil, and with it the syphon, moves under the action of the currents from the cable, a continuous record is left on the paper in a sinuous line made by the ink. Not only did this invention produce a record of the messages, but it enabled far greater speeds to be obtained, and had this been Lord Kelvin's only discovery, he would still have been a very famous man.

About the year 1856 Professor William Thomson took an active part in the laying, for the Atlantic Telegraph Company, of a submarine cable between Ireland and Newfoundland. Great difficulty was experienced, the cable breaking time after time, but eventually one end was landed in Trinity Bay, Newfoundland, and the other in Valentia Bay, in Ireland. Its active life was short. We believe that messages to the number of about 400 were actually sent through it, and that it was in operation for some fourteen days.

Such failures might well have daunted the capitalists; and indeed, for some years nothing more was done. In 1865, however, the "Great Eastern," with Professor Thomson, Mr. Varley, Mr. Samuel Canning, and Mr. De Santz on board, started laying another cable. A thousand miles had been laid when the cable broke, and could not be recovered. The huge steamship returned to England, and nothing more was done till the following July. Then she again started, and again Professor Thomson was on board. This time success was achieved, and America was linked up with the mother country. Moreover, the cable which had been broken during her first attempt was grappled, hauled on board, spliced, and the remainder successfully laid. It is hardly too much to say that the laying of these cables was due in the main to the efforts of Professor Thomson, and on his return, in 1866, he was, with others, knighted by the Lord Lieutenant of Ireland. His services were immediately afterwards secured by a number of cable companies, and practically nothing in the way of cables was done without his advice being taken.

Sir William was at this time much given to yachting, most of his long vacations being spent on his yacht, the "Lalla Rookh." This love of the sea led to the invention of two pieces of apparatus which are now universally employed. The first he brought out in 1872, and it was for the purpose of taking deep sea soundings. The other was the improvement of the mariner's compass. Practically all the world now uses the compass which he devised and patented in 1876, and improved at subsequent dates, and no further description of it is needed than that in place of one large magnet needle, a number—usually eight—were arranged by a particularly clever method of suspension, and a saving of weight of nearly 18 to 1 was obtained. The sensi-

tiveness was greatly increased. The compass is carried in a soft iron screen and is adjusted by means of permanent magnets.

Sir William Thomson, with the object of working out his many inventions more fully, entered into partnership with Professor Fleming Jenkin, F.R.S., and Mr. Cromwell F. Varley, the latter of whom is identified with the use of the condenser in cable making. With their assistance, an automatic signalling key was introduced in 1876.

Among other questions to which Sir William gave his attention was the subject of tides. In 1881 he read a paper before the Institution of Civil Engineers entitled "The Tide Gauge, Tidal Harmonic Analyser, and Tide Predicter.' The tide gauge was different from other tide gauges then existing in certain dynamical and geometrical details, and was an application of an instrument devised by his brother, Professor James Thomson.

Every student of electricity knows of the numerous instruments invented by Lord Kelvin for the measurement of electricity and manufactured by the firm of White, of Glasgow. In 1846, just after being appointed to his professorship, he gave "a mechanical representation of electric, magnetic, and galvanic forces." In the early fifties he wrote a paper entitled "Application of the Principle of Mechanical Effect to the Measurement of Electro-Motive Forces, and Galvanic Resistances in Absolute Units," and was a very active member of a Special Committee appointed by the British Association in 1861 for the consideration of electrical standards. About the year 1855 he produced his absolute electrometer and ring electrometer, which he later on perfected and called the quadrant electrometer, and invented a new astronomical clock. His ampère and watt balances are too well known to be more than mentioned. The same may be said of his ingenious electro-static voltmeters and wattmeters, which were designed by him.

He was almost the grandfather, so to speak, of wireless telegraphy, for he verified the supposition of others that oscillations were set up in the ether by the discharge of a Leydon jar. Herz carried his work several degrees further, and others have gone further still. Lord Kelvin's researches into the size and constitution of atoms, his theory of the ether, his vortex theory, his development of Carnot's theory, and his dynamical theory of heat are historic. His name will always be associated with

his mathematical theories of electricity and magnetism. In short, every branch of physics is the richer by reason of his investigations and discoveries, and a lengthy catalogue would be required to contain all his numerous writings and publications.

Possibly no man had a greater number of distinctions showered upon him. For example, he was four times President of the Royal Society. He was one of the very few to receive the Order of Merit, being one of the first eight to be so honoured. He was P.C.; G.C.V.O.; LL.D., D.C.L.; these titles being conferred by numerous institutions at home and abroad; D.Sc., M.D.; and D.L. He was member of the Prussian Order pour le Mérite; Grand Officer of the Légion d'Honneur; Commander of the Order of King Leopold of Belgium; of the Order of the First Class of the Sacred Treasure of Japan; Foreign Associate of the French Academy; and Foreign Member of the Berlin Academy of Science. In 1891 he was, with Professor Unwin, Professor E. Mascart, Dr. Coleman Sellers and Col. Th. Turrentini, appointed to the International Commission for determining the method to be adopted in obtaining electrical power from Niagara Falls.

He was raised to the peerage by Queen Victoria in 1892, assuming the title of Baron Kelvin of Netherall, Largs. In 1896 he celebrated his jubilee as Professor at Glasgow, and delegates from all over the world came to offer him their congratulations. Three years later he gave up his professorship, though his active business life was by no means ended at this time. He was twice married, and his second wife outlives him.

His was the kindliest of dispositions. He was always ready to lend a helping hand to those in trouble or distress, and, in fact, a life better spent than his cannot be imagined.—*Abridged from "The Engineer," 20th December, 1907.*

Lord Kelvin became a Vice-President of the Junior Institution of Engineers in June, 1895; was present at its Summer Dinner in Glasgow, in 1896, and from time to time in various other ways evinced a warm interest in its development and success. His death occurred at Largs, N.B., on the 17th December, 1907, in his 84th year, the interment taking place in Westminster Abbey.

BASIL PYM ELLIS, who was 57 years of age at his death, which occurred suddenly at Paris, on 5th October, 1907, entered the service of Messrs. John Aird and Sons in 1866, and in 1878

became a partner in the firm. His first work, as assistant engineer, was on the construction of the Millwall Docks, and on extensions of the Southwark and Vauxhall Waterworks, and he was subsequently engaged on contracts for the Birmingham and Colne Valley Waterworks, for the Greenwich and Woolwich Railway, the Beckton Gasworks of the Gas Light and Coke Company, and the Bishopsgate and Aldgate section of the Inner Circle Railway. After being admitted into partnership he took an active share in the execution of numerous important contracts carried out by Messrs. John Aird and Sons, in all parts of the world, including the great Assouan dam in Egypt. Of this he gave an interesting account in a lecture to "The Engineers' Club" in connection with the Institution in March, 1905. A member who intimately knew Mr. Ellis and served under him for some years, wrote in the December (1907) number of *The Journal* an appreciation of his characteristic qualities. (See p. 98 *ante.*) He married in 1878 the eldest daughter of Sir John Aird, and leaves issue two sons and two daughters. His connection with the Institution dated from December, 1906, when he was elected an Honorary Member.

JOHN MACFARLANE GRAY. Little is known of Mr. Gray's early days, but at the time he joined the Institution of Mechanical Engineers in 1865, he was employed as a marine engineer in the Vauxhall Foundry, at Liverpool. He was a prolific contributor of papers to the various institutions to which he belonged, and frequently joined in the debates. Probably the best papers he contributed were those which he read before the Institution of Mechanical Engineers in 1889, on "Ether Pressure Theory," which dealt with the ether pressure theory of thermodynamics applied to steam, and the paper on "The Rationalisation of Regnault's Experiments on Steam." He was a great author on superheated steam, and anything he had to say on the subject was always most interesting and instructive. Mr. Gray was for a great number of years connected with the Institution of Naval Architects, and was one of its earliest members. He joined the Institution in 1870, just ten years after it was opened. In 1880 he was elected to the Council, and in 1904 was made a Vice-President. During his long membership he contributed many papers on marine subjects, and very frequently entered into the discussions, but within recent years was not quite so

active as formerly. He had a very varied experience during the many years he acted as consulting engineer, and for some time had been the chief examiner of engineers to the Board of Trade. Some of his best work was done in connection with steam steering gears, on which subject he was one of the leading authorities in this country. It will no doubt be remembered that he designed and superintended the construction of the steam-steering gear for the "Great Eastern," a work which involved a considerable amount of ingenuity and no little risk. On the suggestion of the late Sir James Anderson, who was commander of that ship, Mr. Gray's invention of the differential gear enabled the steering engine when placed at a distance from the navigating station, to be controlled by the movement of the steering wheel, so that the helm could be made to follow and assume any desired position. The first trial of the "Great Eastern" gear was made in March, 1867, and was successful. It led eventually to the general adoption of steam steering gear, although some time elapsed before the full advantages were realised.—*The Engineer*, 17th January, 1908.

Mr. Gray died at his son's residence, 11 Spottiswoode Road, Edinburgh, on the 14th January, 1908, aged 76. He was elected an Honorary Member of the Junior Institution of Engineers in September, 1890, and in 1892 delivered a lecture before it on "The Theta-phi Diagram of the Thermo-Dynamics of Steam."

RICHARD FORSTER was born at Chapeltown, near Sheffield, on the 22nd December, 1877. He served his apprenticeship at Messrs. Newton Chambers and Co.'s Thorncliffe Iron Works, from 1892 to 1898, and was afterwards placed on the staff, his duties embracing the design and construction of gas apparatus, bridges, roofs and other constructional engineering work. On leaving in 1903, he entered the service of the Horseshay Company as draughtsman, and was subsequently employed in the same capacity by Messrs. Ashmore, Benson, Pease and Co., at Stockton-on-Tees; and at the Midland Iron Works of Messrs. C. and W. Walker, Donnington, Shropshire, whom he left in 1907 on account of an accident and supervening ill-health. Acting on medical advice, he sailed in the following October for New Zealand, but becoming worse had to remain at Cape Town, where he died, in the New Somerset Hospital, on Christmas Day. He was elected a Member of the Institution in December, 1900.

Date Due
